

# U.S. ARMY MEDICAL DEPARTMENT JOURNAL



## U.S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE

*January-March 2004*

Perspective	1
BG Daniel F. Perugini	
From the Commander, U.S. Army Center for Health Promotion and Preventive Medicine	3
BG William T. Bester	
Readiness Through Health – USACHPPM History 1942-2003	5
Health Information Operations: Improving What the AMEDD Communicates	6
Kevin M. Delaney, et al	
USACHPPM Toxicology: Maintaining Readiness and Protecting the Environment	10
Wilfred C. McCain, PhD, et al	
Longitudinal Health Risk Assessment Program	15
MAJ Michael R. Bell, MC, USA, et al	
Making Better Decisions: Using GIS at USACHPPM	21
Jason S. Edmondson, et al	
The U.S. Army's HHA Program: Past, Present, and Future	28
MAJ Timothy A. Kluchinsky, Jr, MS, USA, et al	
Dietary Supplement Use in the Military: Do Army Health Care Providers Know Enough?	36
MAJ Sonya J.C. Corum, SP, USA	
Assessing and Communicating Deployment Radiation Risks in Iraq	39
LTC Mark A. Melanson, MS, USA, et al	
Protecting Military Forces From Unhealthy Levels of Noise During Deployment	44
George A. Luz, PhD, et al	
Addressing Risk Communication Challenges with the Smallpox Vaccine	49
Roxanne D. Smith	
Force Health Protection and Military Drinking Water Supplies	55
W.D. Burrows, PhD, et al	
Deployment Exposure Assessment and the Role of Biomonitoring	60
Coleen Baird Weese, MD	

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# Perspective

## USACHPPM—Supporting and Protecting the Army Community

The U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) traces its beginnings to 1942, when a staff of three formed the Army Industrial Hygiene Laboratory, with a budget of \$3000. The first Army regulation dealing with industrial hygiene was published in 1945 and the small staff soon grew into the U.S. Army Environmental Agency. By 1960, this activity had become the leader in preventive medicine for the Army and occupied several buildings at Edgewood Arsenal, MD. In 1973, the agency became part of the U. S. Army Health Services Command; it was re-designated as USACHPPM in 1994 and headed by an Army Medical Department (AMEDD) general officer. It has continued to grow into an organization with five subordinate commands located at Fort Meade, MD; Fort McPherson, GA; Fort Lewis, WA; Landstuhl, Germany; and Camp Zama, Japan.

The USACHPPM is at the forefront of preventive medicine, with an increasingly imperative role in the day-to-day protection of Soldiers and their families. Its mission is to provide health promotion and preventive medicine leadership and services to counteract environmental, occupational, and disease threats to health, fitness, and, most importantly, readiness. Within the organization, eight directorates oversee the fields of epidemiology and disease surveillance; environmental health engineering; health promotion and wellness; health risk management; laboratory sciences; occupational and environmental medicine; toxicology; and occupational health sciences. Through these directorates, USACHPPM serves a crucial role in the accomplishment of the worldwide Army mission. Keeping the Soldier healthy and providing a safe and healthy working environment for U.S. Army employees are two of the organization's primary goals. During the current period of deployments, USACHPPM is working diligently to protect Soldiers from numerous environmental, biological, and toxin threats.

This issue of the Journal provides an interesting and informative glimpse into USACHPPM's multifaceted research and support activities:

- More than 50 percent of the United States population uses a wide variety of dietary supplements (many of which are unregulated) and health care providers are frequently not aware of their use. The author of *Dietary Supplement Use in the Military: Do Army Health Care Providers Know Enough?*

discusses the results of a web-based survey of over 400 providers concerning their knowledge of eight Specific dietary supplements.



Brigadier General Daniel F. Perugini

Toxicology is responsible for characterization, assessment, and management of toxicological risk. An overview of toxicological evaluation of chemicals and other substances in the U.S. Army supply system is presented in *USACHPPM Toxicology: Maintaining Readiness and Protecting the Environment*. This article further discusses the directorate's role in eco-toxicology within the Army operating environment.

- One of the biggest challenges currently faced by the U.S. Army is the prevention and early detection of preventable chronic diseases and cancer. The *Longitudinal Health Risk Assessment Program* discusses a pilot project created to identify Soldiers at risk for cardiovascular disease, provide electronic data collection, educate participants concerning their risk of a cardiac event, and provide follow-up in the treatment of chronic diseases such as hypertension and elevated cholesterol. This article is of special interest to Soldiers and their families.

- While low-level noise exposure (less than 85 decibels) has been thought not to create adverse health effects, recent troop deployments to Bosnia and Kosovo have proven otherwise. *Protecting Military Forces From Unhealthy Levels of Noise During Deployment* is an interesting, comprehensive review of testing that revealed how low-level noise near military airports significantly impacted on individual sleep habits and other noise-sensitive activities.

- The management of a viable water supply is a crucial component in conserving the U.S. Army's fighting strength. In both garrison and field operations, the USACHPPM works closely with the Corps of Engineers, the Quartermaster Corps, and the AMEDD to provide safe drinking water. The author of *Force Health Protection and Military Drinking Water Supplies* provides a discussion of the inter-command planning and coordination that are vital to successfully accomplishing the water distribution mission.

- For over a year the USACHPPM has been working in

conjunction with the Military Vaccine Agency to develop and implement a viable risk communication strategy to assist in effectively implementing the Smallpox Vaccination Program. *Addressing Risk Communication Challenges with the Smallpox Vaccine* is a comprehensive review of the various methodologies used by the Health Risk Communication Program to effectively educate Soldiers and their families on the Smallpox vaccination effort.

- The protection of Soldiers from environmental risks during combat operations is another one of the USACHPPM's vital ongoing missions. *Assessing and Communicating Deployment Radiation Risks in Iraq* tells the story of the Special Medical Augmentation Response Team-Preventive Medicine and their efforts to assess the risk of radiation exposure to Soldiers guarding a large Iraqi nuclear research facility during *Operation Iraqi Freedom*. This in-depth examination of the team's extraordinary work gives the reader a more complete understanding of the team's missions and capabilities.

- The Geographic Information System (GIS) is a computer-based system designed to process and store digital map information. This allows multiple layers of information to be archived and analyzed to perform operations such as addressing data queries, answering geographic questions, and establishing patterns or trends. *Making Better Decisions: Using GIS at USACHPPM* provides a comprehensive description of GIS versatility and how it can assist planners and decision makers in producing meaningful recommendations to protect the health of military and civilian communities.

- Another ongoing USACHPPM mission to protect

Soldiers is the multifaceted Health Hazard Assessment Program developed to eliminate or control those identified or potential health hazards associated with the utilization of weapons, equipment, clothing, and other materiel systems. In the article *The U.S. Army's Health Hazard Assessment Program: Past, Present, and Future*, the authors discuss the program's importance to the acquisition community and its viability to materiel program managers in their evaluations of weapons systems' health and safety hazards.

- The focus of *Deployment Exposure Assessment and the Role of Biomonitoring* is the determination of the extent of exposure to various potential toxins during the deployment phase of operations. The author raises the question: is biomonitoring for these toxic agents during both pre-deployment and post-deployment helpful in determining whether or not significant exposure has occurred in a theater of operations? She concludes that biomonitoring can be a powerful investigative tool when employed properly in the sustainment of Soldier health and readiness.

- It is now close to 3 years since the USACHPPM established their Health Information Operations, with the mission of systematically evaluating the precedence of current and potential public health threats and developing/distributing countermeasures information to Soldiers, their beneficiaries, the military leadership, and health care providers. *Health Information Operations: Improving What the AMEDD Communicates* details how the organization was created to assure that viable, accurate information is disseminated through a wide variety of print and automation media.

## **Spurgeon Neel Award Writing Competition to Continue**

Beginning with this edition of the AMEDD Journal, the Spurgeon Neel Annual Award moves into its second year of competition. Named in honor of Major General Spurgeon H. Neel, first Commanding General of U.S. Army Health Services Command (now U.S. Army Medical Command), the award competition is open to all federal employees, military and civilian, as well as nongovernment civilian authors who submit manuscripts for publishing consideration by the Journal.

The award is presented to the author(s) of the Journal article that best exemplifies the history, legacy, and traditions of the Army Medical Department. It is underwritten by the Army Medical Department Museum Foundation and includes a \$500 monetary prize and a special medallion. There was no winner declared in the 2003 competition.

A the time of submission, the manuscript must be original work, not pending publication in any other periodical. It must conform to the Writing and Submitting Guidelines published in each edition of the Journal.

Additional details concerning the Spurgeon Neel Award may be obtained by contacting the Editor, AMEDD Journal ([bruce.nelson@amedd.army.mil](mailto:bruce.nelson@amedd.army.mil)) DSN 471-6916/Comm 210-221-6916.

# **From the Commander, U.S. Army Center for Health Promotion and Preventive Medicine**

## **Brigadier General William T. Bester**

The U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) provides worldwide technical support for implementing preventive medicine, public health, and health promotion/wellness services in support of America's Army and the Army Community, both in garrison and especially during deployments.

The Center is divided into eight technical directorates to accomplish its worldwide mission. These directorates, Occupational and Environmental Medicine, Environmental Health Engineering, Health Risk Management, Epidemiology and Disease Surveillance, Health Promotion and Wellness, Laboratory Sciences, Occupational Health Sciences, and Toxicology, along with the operations and administrative support functions, enable the Center to implement operational preventive medicine. The unique nature of the Center's workforce emphasizes flexibility, adaptability, and a multi-disciplined approach in providing technical products to its Army customers. Professional disciplines represented include chemistry, biology, health physics, engineering, occupational and preventive medicine (physicians), dentistry, occupational and physical therapy, optometry, epidemiology, audiology, nursing, industrial hygiene, toxicology, entomology, veterinary medicine, exercise physiology, nutrition, and health promotion to name a few. Perhaps the best way to get an idea of the breadth of technical products and services delivered by USACHPPM is to assess a summary of recent projects that have been worked by this group of outstanding professionals.

- The Special Medical Augmentation Response Team – Preventive Medicine (SMART-PM) is one of a series of rapid response teams formed and trained to provide technical support in the event of natural or man-made disasters and terrorist attacks. There are three SMART-PMs worldwide. They are located at USACHPPM-Main, USACHPPM-Europe, and USACHPPM-Pacific. These teams are trained and equipped to respond to a wide variety of emergencies including the “9/11” rescue operations at the Pentagon, the anthrax contamination of the Hart Senate Building and the District of Columbia Post Office, and recovery operations at Fort Monroe, VA, from the destruction caused by Hurricane Isabel. There are also three Smallpox Epi Response Teams (SERT) within the Army. They are trained to respond within hours to a potential smallpox outbreak anywhere in the world. Their function is to augment local medical assets and liaison with the civilian response teams.



- Since September 2001, USACHPPM has been assisting the U.S. Central Command (USCENTCOM) and Component Commands with deployment occupational and environmental health surveillance (OEHS) activities. These efforts include pre-deployment support by identifying potential OEH hazards, deployment support with sampling and analytical services, and post-deployment support with the archiving of OEHS data. Two examples of this support were at the Karshi-Khanabad (K2) Airfield in Uzbekistan and Ash Shuiaba Port in Kuwait. A USACHPPM SMART-PM deployed out of USACHPPM-Europe to assist USCENTCOM with identifying and quantifying OEH hazards during Operation Enduring Freedom. At Ash Shuiaba, the only deep-water port in Kuwait, USACHPPM located the Mobile Ambient Air Monitoring Station used to collect real time, air quality data to document known and potential air exposures. Both of these efforts were critical in maintaining an open airfield at K2 and a port at Ash Shuiaba in the face of concerns about the environment by service members based at both locations.

- Risk communication concepts and practices continue to evolve in the face of a changing world, and USACHPPM's Health Risk Communication Program (HRCP) is helping lead the way. Since the events of “9/11,” interest in risk-related issues has dramatically increased. The HRCP's risk communication capabilities have expanded to address these needs by integrating communication considerations into the risk

management process so that all stakeholders can work collaboratively to address complex risk issues. The HRCP's training and consultation services have successfully been integrated throughout all levels of Department of Defense, to include Homeland Security, health, disease surveillance, deployment, vaccination, environmental, and workplace issues.

- The Industrial Hygiene Field Services team routinely works with the Army to evaluate potential sources of occupational hazards of any new vehicles or pieces of equipment being fielded and tested for use by our Army Soldiers. Our most recent evaluation has been with the military's newly acquired Stryker Family of Vehicles. The method designed to collect this data is called the *Soldier Occupational Hazard Assessment* (SOHA). The SOHA is intended to capture, measure, and record any potential health hazards associated with operating any newly acquired military equipment and to provide this information to the manufacturer so that any identified hazards can be addressed.
- The Radiologic Chemistry team of the Center's Directorate of Laboratory Sciences has developed a highly sensitive method for detecting depleted uranium in human urine. This is important in determining if a Soldier has been exposed to depleted uranium and in calculating the health risks if an exposure has occurred. The method measures both the total amount of uranium in the individual and identifies if the uranium is from a natural or depleted uranium source.
- The Laser/Optical Radiation Program has been active

in assessing new field military laser systems that are used for surveillance, communications, range finding, and target designation in Iraq. Lasers can pose a significant risk to troops in combat if appropriate laser eye protection is not used.

- Prior to deploying, the health of each service member is assessed to ensure his or her medical fitness and readiness for deployment; and at the time of redeployment, the health of each service member is again assessed to identify medical conditions and/or exposures of concern to ensure timely and comprehensive evaluation and treatment. Service members complete both pre- and post-deployment health assessment forms, which are routinely sent to the Army Medical Surveillance Activity (AMSA). The AMSA is a part of USACHPPM and is the central epidemiological resource for the Army providing regularly scheduled and customer-requested analyses and reports to policy makers, medical planners, and researchers. The AMSA scans, enters, and archives the health assessment forms data into the Defense Medical Surveillance System. In general, service members who have been deployed since September 2002 have assessed their overall health as "good" to "excellent."

The extensive technical expertise of staff subject matter experts, years of experience, and unique health-related abilities provide the foundation to focus on these special concerns within the military community. The following articles give a more in-depth perspective of important initiatives and present a cross section of work efforts throughout the Center focusing on various projects, outcomes, and lessons learned.

# **Readiness Through Health**

## **USACHPPM HISTORY**

### **1942 – 2003**

The U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) lineage can be traced back over 50 years to the Army Industrial Hygiene Laboratory (AIHL). That organization was established at the beginning of World War II and was under the direct jurisdiction of The Army Surgeon General. It was originally located at the Johns Hopkins School of Hygiene and Public Health, with a staff of three and an annual budget not to exceed three thousand dollars. Its mission was to conduct occupational health surveys and investigations within the Department of Defense (DOD) industrial production base which proved to be beneficial to the Nation's war effort.

In October 1945, AIHL was transferred to Building 330 at what was then known as the Chemical Warfare Center, Edgewood Arsenal, MD. At that time, Army Regulation 40-220, Industrial Medical Program, was published as the first regulation on industrial hygiene. This requirement turned out to be a milestone in preventive medicine in the Army. From 1940 to 1960, AIHL's mission and personnel continued to expand until it occupied 14 buildings and became the U.S. Army Environmental Hygiene Agency (USAEHA).

In 1964, Congress appropriated funds for the construction of a proposed new building to be located on Edgewood Arsenal. The Wesley C. Cox building, named in memory of the commander of the laboratory (AIHL) from 1946 to 1953, was dedicated on 3 October 1967. The USAEHA headquarters remained in this building until 1995 when it relocated to Building 1930.

In 1973, USAEHA became a subordinate command of the U.S. Army Health Services Command. The following year, it was given command of the health and environmental resources of the Army Medical Laboratories. These assets are now subordinate commands with locations as follows: USACHPPM-North, Fort George G. Meade, MD; USACHPPM-South, Fort McPherson, GA; and USACHPPM-West, Fort Lewis, WA. The USAEHA remained as an internationally known Agency with its expanded mission to support the worldwide preventive medicine programs of the Army, DOD, and other Federal agencies when directed by the U.S. Army Medical Command or the Office of The Surgeon General, through consultations, support services, investigations, and training.

On 1 August 1994, USAEHA was re-designated as the USACHPPM with provisional status and a general officer leadership. The USAEHA remained an active organization throughout 1994. Both organizations existed simultaneously. This preserved as much stability as possible and allowed for a well-planned transition. On 1 October 1995, USACHPPM became fully functional.

In 1994, the 10th Medical Laboratory, located at Landstuhl, Germany, came under the operational control of USACHPPM. In 1995, the 10th Medical Laboratory was inactivated; USACHPPM-Europe was activated; and the Environmental Health Engineering Agency at Sagami, Japan, was re-designated USACHPPM-Pacific. In 1997, USACHPPM-Pacific relocated from Sagami to Camp Zama, Japan.

Within the past year, USACHPPM has assumed command and control of the Army Physical Fitness Research Institute (APFRI), located at Carlisle Barracks in Pennsylvania. The APFRI seeks to achieve national preeminence in age 40 and over health and fitness programming through research, education, and outreach.

The mission of USACHPPM is to provide health promotion and preventive medicine leadership and services to counter environmental, occupational, and disease threats to health, fitness, and readiness in support of the National Military Strategy. Its vision is to be the world-class center of excellence for the systematic prevention of environmental, occupational, and disease threats to the health performance of individuals and populations.

The USACHPPM embraces the Army values of loyalty, duty, respect, selfless service, honor, integrity, and personal courage. The organization is committed to anticipating, preparing, and shaping our tomorrow while responding proactively to the challenges of today. It has become increasingly involved in the international area. Our scientists and health professionals deploy to many nations helping to shape the international environment, facilitating foreign alliances, and fostering goodwill. Preventive medicine is thriving and the momentum will continue.

# **Health Information Operations: Improving What the AMEDD Communicates**

Kevin M. Delaney†  
Lorraine Bell, PhD††  
Rachel C. Gross, PhD†††  
Farhana Lotlikar††††  
Lola J. Daniels†††††

## **Introduction**

With the advent of the Internet, average people are able to access vast amounts of information with relative ease. Some of that information is scientifically valid. Some is not. Deciding what information will form the basis of an individual belief or attitude is a complex process, and those who are left to wade through highly technical information can easily come to scientifically invalid conclusions. Unfortunately, a great deal of the information available on health and medical topics is more or less propaganda supporting a specific agenda, and the Internet allows people with these agendas to project their ideas in a manner unheard of until now. The U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) established their Health Information Operations (HIO) in response to the rapid emergence of a number of public health and preventive medicine issues in the mainstream media. In addition to the general health information campaigns, HIO has assumed responsibility for the development and distribution of health information products to support deploying, deployed, and redeploying service members.

The HIO had its genesis amid a number of emerging health issues in late 2000. The first issue that came to the forefront was the status of Bovine Spongiform Encephalopathy (BSE), better known as “Mad Cow Disease,” and the human form of the disease variant Creutzfeld-Jacob Disease (vCJD).<sup>1</sup> At the time, European health officials were growing increasingly concerned that the limited number of vCJD cases was due to the long latency period of the disease. As time passed, they expected that there would be significant increases in reported cases of the illness. The situation in Europe had particular significance for the military community. Although there had been no cases of BSE reported in the U.S. and risk was considered very low (and still is), service members who were stationed or on temporary duty in Europe were at a greater risk. Although overall risk was assessed as very low, Army leaders were interested in what type of response and information campaign the Army Medical Department (AMEDD) was mounting. As the issue worked its way deeper into the preventive medicine community, it became obvious that the

Army was not engaged in any significant campaign on the issue. In stepping up its efforts relative to this issue, the Army realized that a central point of coordination would be necessary. A cell at USACHPPM was set up to deal with the issue and, in particular, to ensure that: (1) assigned tasks were being completed; (2) information was being fully integrated and staffed to appropriate experts; (3) information developed was being appropriately distributed; and (4) information was being kept up-to-date and passed, as necessary, to Army leaders.

As the cell executed its responsibility, other issues emerged, the first being Foot and Mouth Disease. Response to this health issue was much more rapid and easier to effect since there was already a starting point for developing and coordinating information. With other important issues emerging, the decision was made to look at establishing HIO for the long-term.

At the direction of the Surgeon General of the Army, USACHPPM formally established HIO in Apr 01. In the months leading up to its formal stand-up, there was significant analysis and debate as to how to best complete the mission that HIO was assigned. The HIO mission was, and is still, to identify and prioritize emerging and potential preventive medicine/public health threats, both real and perceived, in a systematic manner; and develop and appropriately distribute information to convey those threats and appropriate countermeasures to service members, their families, military leaders, health care providers, and other appropriate audiences (<http://chppm-www.apgea.army.mil/dcsops/Health.aspx>). The HIO was initially staffed with a senior Scientist/risk communication expert and a 72D Environmental Science Officer. A Doctor of Veterinary Medicine with a Masters in Public Health was also added.

In addition to initial staffing, where to organizationally align the new mission was an essential issue. Given that the primary mission of the HIO was to coordinate and ensure appropriate distribution of information, Operations was the best organizational fit. The HIO was established as the HIO Division within the USACHPPM Deputy Chief of Staff for Operations. The HIO is currently staffed by a civilian chief, a 72D

Environmental Science Officer, an environmental engineer, two PhD-level medical analysts, and a product administrator. One medical analyst is responsible for development of health education products, and the other analyst conducts monitoring and evaluation activities. The product administrator coordinates services related to processing and shipping health information products.

In the wake of the 1991 Persian Gulf War, a number of individuals and groups provided explanations for the symptomatic illness that has come to be called “Gulf War Illness.” Some of the explanations/ideas put forth had scientific merit, while others did not. Ideas are still being put forth from a wide range of sources. Regardless of the explanations for the illness, it is clear that Soldiers should have received more information at the time. One has to wonder how different things might be for at least some of those affected by the illness. As HIO came into being, USACHPPM realized that it has a responsibility to provide service members and their families (as well as other interested parties) with the best information available. If that information can be provided in a timely and understandable way, then some of the confusion that can grow out of such complex situations can be alleviated.

## Current Functions

The primary function of HIO is to disseminate health information products to service members, their families, Army leaders, and other interested parties in a timely fashion. The HIO team strives to maintain the Health Information Products in a state of readiness for dissemination. This is of utmost importance, as health situations often occur without notice. Even when a health issue can be anticipated, products need to be developed quickly and made readily available. Because products are often used in the field, it is imperative that products be easy to access and order. For this reason, all HIO products are posted on the USACHPPM website and can be easily ordered (<http://chppm-www.apgea.army.mil/fs.htm> and <http://chppm-www.apgea.army.mil/tg.htm>).

The products are also printed in bulk to be available by request. There is a 2 to 3 workday turnaround for requested materials. The product administrator contacts installations monthly to ensure they maintain an adequate supply of health information materials. These products are created in compliance with well-researched methods of health communications and are written at reading levels concordant with the target audience for the product.<sup>24</sup>

The HIO creates products that educate specified audiences about different health topics. Products are either requested by different departments within the AMEDD or the Army, or are created by the HIO team in anticipation of requests when a new

health issue has come to light. Often, HIO creates these products in conjunction with other departments within USACHPPM and the AMEDD when specific expertise is needed. For example, if a product concerning malaria is requested, HIO will produce the product in conjunction with the USACHPPM Entomology Program and the Directorate of Epidemiology and Disease Surveillance (DEDS). Products can be in the form of brochures, web pages, fact sheets, pocket cards, and posters. In the last year, over 4 million health information products have been distributed to Army leadership, Soldiers, family members, and other stakeholders.

One of the most visible and widely disseminated products of HIO is the Staying Healthy Guide (SHG). The HIO has created an inventory of SHGs. These brochures are given to deploying Soldiers and convey the health risks of the area to which they are being deployed. In addition to SHGs that pertain to specific areas of the world, there are also SHGs that pertain to different climates or conditions (for examples, Graphic Training Aid [GTA] 08-05-060, *A Soldier's Guide to Staying Healthy at High Elevations*).<sup>5</sup> The SHGs can be printed from the USACHPPM website or can be ordered from HIO directly. There is an advantage to ordering the SHGs from HIO, as these guides are printed on paper that is waterproof and tear-proof. The inventory of SHGs is not static; new SHGs are often created in response to a new deployment or request, and existing SHGs are periodically updated.

The HIO not only produces paper products, but also maintains the USACHPPM home page (NIPRNET and SIPRNET). The HIO posts its own products as well as the products of other programs within USACHPPM. Many of the products that are posted on the home page represent health topics that are of high importance to the Army. As with the other products HIO creates, web page topics can also be requested. In addition to maintaining the home page, HIO also posts a weekly health tip on this page. This “Health Tip of the Week” makes readers aware of specific health issues and links them to websites where they can obtain more detailed information. The HIO has administrative rights to the “My Medical” section of the Army Knowledge Online (AKO) Portal. The information posted on the AKO site mirrors that of the USACHPPM site. In addition, divisions within USACHPPM and various departments within the Army can request items be posted in the “My Medical” section of the AKO site.

Finally, HIO disseminates “HIO Weekly Updates” for all of the AMEDD. The updates are intended to keep the AMEDD abreast of current and emerging global health issues, both real and perceived, that may affect members of the military and their families so that HIO can anticipate their concerns. Topics range from current health research findings to infectious disease surveillance. Many of the topics that are listed in the

HIO Weekly Update may appear at first glance to be of questionable value to the military medical community; however, if the clinical community is aware of issues being discussed by the general public, they can be better prepared to deal with the concerns of their beneficiaries. The HIO Weekly Update is also posted on the USACHPPM website as well as the AKO Portal (<http://chppm-www.apgea.army.mil/hiouupdate>).

Another key function of HIO is the monitoring and evaluation of health information products. Monitoring includes regular observation and recording of activities that are taking place, with routine gathering of information on specific aspects of these activities. This helps to identify where problems are and to find solutions to the problems. For example, HIO: (1) Examines information to determine whether the reading level is appropriate for the Soldier population. (2) Reviews materials for the most up-to-date information. (3) Monitors the number and type of products dispersed. (4) Monitors response times for distribution of products. The HIO also ensures activities are carried out properly by the appropriate people and completed on time. Evaluation involves baseline and follow-up field surveys that measure certain aspects of knowledge, access to information or prevention/product availability. The evaluation process provides information that determines the need for adjustments to programs, plans, and budgets. As a feedback mechanism, monitoring and evaluation keeps HIO responsive to changing conditions.

The HIO has supported Operation Iraqi Freedom (OIF) by creating/co-creating and disseminating health education materials that are relevant to deploying, deployed and redeploying Soldiers. The HIO has been able to rapidly develop products to support the theater of operations. The quick development of these products is possible due to a number of reasons:

- The willingness of subject matter experts throughout USACHPPM and the AMEDD to provide HIO with health information related to a requested product.
- The ability of medical analysts to quickly develop product prototypes.
- The willingness and ability of the Visual Information Division and the Publications Management Division to expedite HIO products and the excellent coordination between these two USACHPPM divisions and the HIO product administrator.
- Access to the Aberdeen Proving Ground and Government Printing Office printing plants for expeditious printing of HIO products.

Soldiers deploying in support of OIF were given GTA 08-

05-062, *Guide to Staying Healthy*, and SHG 003-0302, *A Soldier's Guide to Staying Healthy in Southwest Asia*, as well as other relevant regional SHGs.<sup>6,7</sup> In addition, HIO created a generic medical threat briefing that can be tailored by local personnel to accommodate the specific needs of deploying Soldiers.

Soldiers also received several HIO products while deployed in Iraq. One such product was a poster that displays all of the poisonous snakes in the U.S. Army Central Command region and gives Soldiers tips on how to prevent snakebites and what to do if a snakebite should occur. *A Soldier's Guide to Oil Well Fires/Sabotage*, was distributed; this document explains the dangers of oil well fires, the health hazards associated with these fires and how to protect oneself from these hazards.<sup>8</sup> Pocket cards for leishmaniasis prevention and protection from sand flies were produced and shipped. The HIO was also responsible for the dissemination of heat and sun injury prevention products (<http://chppm-www.apgea.army.mil/heat/>).

The HIO ensures health care providers are supplied with up-to-date information on how to best prevent and treat disease and injury in the field. The HIO maintains a substantial cache of materials that the health provider can access via the USACHPPM website. Should a need become apparent to the health provider in the field, products can be developed and shipped quickly to the field.

Upon redeployment, Soldiers received SHG 017-0502, *A Soldier and Family Guide to Redeploying*.<sup>9</sup> This guide provides information intended to address issues and concerns relative to redeployment. The HIO also created a product that provides guidance as to how and why Soldiers should continue taking malaria prophylaxis upon leaving the theater.

The HIO not only created and disseminated printed (hard copy) materials during OIF, but also posted, and continues to post, information related to OIF on the USACHPPM website and the AKO Portal. Since the website and AKO Portal are accessible to Soldiers as well as their family members, the information posted is relevant to both audiences. Posted information includes: (1) a warning against human use of flea and tick collars meant for animals; (2) the prevention of insect-borne diseases such as malaria and leishmaniasis; and (3) links to vaccine and medication information.

## Future Functions

The HIO is working toward expanding its role with the USACHPPM DEDS. If a disease outbreak occurs in a theater of operations or in areas where the military is deployed, DEDS is typically alerted to the outbreak in order to support the deployed unit in their efforts to reduce morbidity and mortality

to deployed military personnel. When necessary, health information products that address health promotion and preventive medicine can be developed and distributed to the affected persons.

The HIO is beginning to conduct its own research to determine what types of products need to be developed or revised. Future types of research will include surveying personnel to find out what types of products are desired and studying the knowledge, attitudes, and behavior of personnel to determine what topics need to be addressed. This continuous monitoring and evaluation of HIO products are key components of the HIO program and an integral part of HIO long-term effectiveness. The HIO is also in the process of creating a web page where all USACHPPM products can be ordered and tracked.

It will soon begin to disseminate a classified version of the HIO Weekly Update. This version will discuss health issues relevant to classified missions. Also, HIO will apply lessons learned on how to disseminate products to remote regions overseas more rapidly.

## Summary

The HIO was established to facilitate the dissemination of appropriate health information to service members and their families, as well as Army leaders and other interested parties. To achieve this, HIO creates and disseminates a number of products including health education products, regional and topical SHGs and the HIO Weekly Update. The HIO also posts health information on the USACHPPM website and the AKO Portal.

Technical directorates at USACHPPM are consulted by the HIO to obtain information on potential occupational and environmental exposures. The HIO creates the appropriate educational materials that address these issues and disseminates them to Army leadership, Soldiers, family members, and other stakeholders.

The HIO monitors its program and evaluates its products. Monitoring the program is done to identify where problems are and to find solutions to the problems. It also ensures activities are carried out properly by the appropriate people and tasks are completed on time. Products are evaluated in order to determine what adjustments might be needed.

In the future, HIO will conduct its own research to determine what types of products need to be developed. In

addition, HIO will soon begin to disseminate a classified version of the HIO Weekly Update. The HIO products can be found online at: <http://chppm-www.apgea.army.mil/>.

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# **USACHPPM Toxicology: Maintaining Readiness and Protecting the Environment**

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## **Introduction**

Soldiers in the U.S. Army are the most technologically advanced warfighters in history; they are able to defeat adversaries swiftly and commandingly. Advantage gained in warfare is due in part to the constant advances in technology. With these advances come new equipment and new materiel that could result in exposures to unknown and potentially toxic substances. These exposures may adversely affect individuals and/or the environment. The major part of the mission of the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) is to eliminate, reduce, or manage these threats. To this end, the Directorate of Toxicology (DTOX) plays a vital role. The DTOX is comprised of two programs, each having unique functions while following the basic tenets of applied toxicology: characterization, assessment, and management of toxicological risk.

The ultimate goal and rationale for toxicity testing is to successfully manage risk. To do this, the risk must first be determined or assessed. In simplest terms, risk is based on the toxicity of a substance and the likelihood of exposure to it in a given application. Characterization studies garner route- and dose-specific toxicity data used in the risk assessment. For example, in regard to the overall process, some substances are very toxic only when ingested but are used in applications where dermal contact is more likely. In this case, managers would emphasize precautions to manage the threat of ingestion with less emphasis on methods/engineering to help prevent skin contact. The USACHPPM and specifically DTOX quantify this process, which ultimately guides managers as to the extent a risk should be managed. The products and the processes described in this article are very similar regardless of the target to be protected, human or nonhuman.

## **Toxicology**

*Toxic Risk Assessment.* For some substances, a wealth of

knowledge is available to make sound assessments for a given exposure scenario. For other substances, little is known and risk can only be surmised by association with substances of comparable molecular size, shape, chemical aspects, etc. These associations are generally used only as a guide to planning more definitive studies.

Materiel being developed for Army use and materiel not currently in the Army's inventory must be evaluated for toxic effects prior to their use. The Surgeon General of the Army has assigned the responsibility to USACHPPM. As USACHPPM's official representative, DTOX evaluates a wide range of materiel. Two basic types of assessments are conducted: the Toxicity Clearance (TC) and the Health Hazard Assessment (HHA). The need and authorization for these processes are identified in Army Regulation 40-5, *Preventive Medicine*, and Army Regulation 40-10, *Health Hazard Assessment Program in Support of the Army Materiel Acquisition Decision Proce.s*.<sup>1-3</sup>

A TC involves a toxicological evaluation of chemicals and substances prior to introduction into the Army supply system. TCs are granted for specific applications. Approval for one situation may not cover a different usage if the exposure scenario has changed. It is possible that a TC may not be granted because of insufficient toxicological data, in which case additional toxicological testing would be recommended. Additional toxicity testing requirements will vary with the intended use of the product and its chemical nature. It is also possible that additional procedures, equipment, or controls may be recommended for the safe use of a particular substance in a specific application.

The HHA Program, managed for the Army Surgeon General by USACHPPM, is designed to identify and eliminate or control health hazards associated with the lifecycle management of weapons, equipment, clothing, training devices, and materiel systems. Toxicity issues are part of the assessment

process. The DTOX is generally part of the team that performs HHAs and provides input on toxic hazards based on possible exposure and use of the materiel in question. The HHA routinely discovers substances not covered by a TC but proposed for use. If the substance is specific to a system being evaluated, it will be covered in the HHA process with input from DTOX and other USACHPPM directorates. If the substance is generic across systems, it should be covered by a TC for each specific use. For those substances for which little or no data is available, full characterization is necessary.

**Toxic Risk Characterization.** The characterization of toxic risk is performed by the Toxicity Evaluation Program (TEP). Testing and evaluation of products are mandated by the Code of Federal Regulations and are conducted by the TEP under Good Laboratory Practice guidelines set forth by the Environmental Protection Agency and the Food and Drug Administration.<sup>46</sup> The results of these studies are often required for product registration. The TEP performs both acute and subacute *in vivo* testing in facilities accredited by the Association for Assessment and Accreditation of Laboratory Animal Care International. All animal studies require a written proposal, approval of the Institute Animal Care and Use Committee, quality assurance oversight, and a written final report. Principal investigators and study directors are ultimately responsible for study conduct. The product of these evaluations is data on exposure, dose, and route with some data on target organs involved.

Substances in question are initially evaluated for acute effects. Generally, initial testing is determined by the potential route of exposure and anticipated product toxicity. Acute exposure evaluation of a product includes approximate lethal dose, primary skin and eye irritation in rabbits, skin sensitization, and acute oral or inhalation studies in rats. With information from the acute studies, a basic toxicity evaluation is made and concentrations are determined for subacute testing protocols.

Subacute and subchronic tests are planned according to the findings in the acute testing and may include 14- and 90-day feeding studies, 21- and 90-day dermal studies, developmental studies in rats and rabbits, photochemical irritation studies, dermal penetration studies, functional observation battery, as well as more specialized *in vivo* and *in vitro* testing procedures. Clinical observations as well as pathological and biochemical evaluations from the animal studies are used to determine the lowest concentration of the product that produces an observable effect for each test. This information is used in the assessment process.

Testing of substances includes *in vivo* (in the animal) or *in vitro* (bench top) analysis. *In vitro* testing is either performed in the facilities at USACHPPM or contracted to reliable sources

within or outside the Federal Government. These *in vitro* tests primarily evaluate mutagenic potential of a product and include the *Salmonella-E. coli*/mammalian-microsome reverse mutation assay, mouse micronucleus assay, mouse lymphoma forward mutation assay, chromosomal aberrations in Chinese hamster ovary cells, and rodent dominant lethal assay.

The TEP is currently conducting a number of studies on several products. These include new candidate substances for arthropod repellants, munitions and their by-products, and nanoparticles.

Once sufficient data has been obtained from the various characterization studies, the lowest concentration where an adverse effect is observed is determined. This data is often presented to regulators who, in conjunction with DTOX and other USACHPPM directorates, determine safe levels of exposure for the product via the risk assessment process. Often, products are improved and additional testing becomes necessary to alter the designated safe levels. An example of this would be the fog oil used for smoke and obscurant operations. In order to lower the toxicity from exposure to fog oil, the oil was hydrotreated at the refinery to reduce the level of polycyclic aromatic hydrocarbons. Results from the additional testing indicated that the reduced toxicity warranted a less stringent safety requirement. This information was presented to regulators and new safety requirements and guidelines were established.

**Risk Management.** Once toxic risks have been characterized and assessed, appropriate measures for a product's safe use are determined. This process is often as simple as container labeling and the use of personal protective equipment. Product use may be limited to use in nonoccupied areas. Often, although Federal regulations and guidelines are met for a product or operation, local requirements may prohibit their implementation. The DTOX, in its role as envoy for the Surgeon General, must meet with local and Federal regulators in order to reach a solution. This process requires a certain amount of finesse. For instance, the Colorado Air Quality Control Board does not allow substances into the air that produce opacity although many other states do not have such a requirement. This became a problem when smoke and obscurant exercises were conducted at Fort Carson. The DTOX provided substantial information on the safety of fog oil as well as air modeling information. The DTOX worked closely with the Department of Environmental Compliance and Management from Fort Carson and the Colorado Department of Public Health and Environment. The DTOX and the Department of Environmental Compliance and Management argued the Army's position to the Board and persuaded the Board to waive the regulation.

## **Ecotoxicology**

While much of the AMEDD efforts focus on human health-related issues, ecotoxicology plays an important role in military readiness and in maintaining the Army as a responsible steward of the environment. Ecotoxicology is the science of studying and interpreting toxicity information in the context of ecological systems. Functionally, this often involves using nonstandard laboratory models, such as birds, reptiles, and amphibians for toxicity testing. Since the Army is required to comply with current environmental legislation, such as the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA or Superfund), ecotoxicological studies provide information necessary for responsible and cost-efficient compliance allowing training to continue without distraction.<sup>7</sup> Efforts within the Health Effects Research Program (HERP) in DTOX are aimed primarily toward: (1) developing methods and tools for ecological risk assessment, (2) providing technical support to the Army, and (3) filling important ecotoxicological data gaps. The following paragraphs provide an overview of ecotoxicology in Army environmental management emphasizing the efforts of the HERP. The development of new animal models, such as lizards, birds, and salamanders for toxicity testing and tools to facilitate Army ecological risk assessments are discussed.

*Novel Animal Models for Toxicity Testing.* Frequently, training, manufacturing, and packing activities can lead to contamination of the environment. Even though efforts are made to reduce or eliminate the potential for contamination, it is impossible to avoid it completely. Federal environmental laws such as the CERCLA of 1980 (or Superfund) and other Federal and state laws require an evaluation of the site-related ecological effects. The process designed to determine whether contaminant-induced effects to ecological systems require remedial action is called Ecological Risk Assessment (ERA). An integral component of all ERAs is an understanding of the toxicity of a particular compound of interest to a particular receptor (organism). An example would be the toxicity of an environmental contaminant such as polychlorinated biphenyls (PCBs) to bird species such as the bobwhite quail. The more specific the data, the less uncertainty and the closer the ERA process can get to a reliable cleanup value. This is important, as errors in assessing risk could lead to deleterious effects (if the value is too high), or to unnecessary expense (if the value is too low), at the cost of other environmental efforts. Hence, there is a strong need for robust toxicological data.

For the example mentioned above, the most useful data for an ERA would be the toxicity of PCBs to bobwhite quail. While laboratory toxicity data and the focus of an ERA can match up, this is often not the case. More likely, the effects of a particular compound on a given receptor must be extrapolated

from data on the effects of that compound on a *different* receptor. This is an oft-used approach; however, as stated previously, it introduces uncertainty that can be costly. Historically, the most widely used animals for toxicity testing have been laboratory rodents such as the Wistar F44 laboratory rat. Data obtained from studies on these organisms have been extremely useful in human health risk assessment and health protection and are used in ERAs with regularity. For mammalian receptors in an ERA, the use of toxicity data obtained from laboratory rodents would likely be reflective of what may occur to a receptor of interest such as a field mouse. However, in some cases, the receptor of interest is a bird, reptile, or amphibian. Given the differences in physiology, behavior, and life history, there are likely to be differences in how these different classes of terrestrial vertebrates respond to a given toxicant.

The HERP has worked to develop and/or evaluate new laboratory animal models to reduce uncertainty in ERAs. Specifically, the HERP has worked with birds, amphibians, and reptiles. To date, bird studies have included evaluating the effects of trinitrotoluene (TNT) on male and female white carnea pigeons, *Columba livia*. Studies in progress or planned for the future include a series of studies on the toxicity of a TNT by-product, 2,4-dinitrotoluene (2,4-DNT), to bobwhite quail (*Colinus virginianus*) as well as determining the bioavailability of copper to pigeons. Amphibian studies have included several different approaches and species. Tiger salamanders (*Ambystoma tigrinum*) were used to evaluate the toxicity of PCBs and TNT via both dietary and dermal exposure routes. The red-backed salamander (*Plethodon cinereus*) is a lungless species used to assess the dermal toxicity of the explosives trinitrotetrazine (RDX) and 2,4-DNT. This species is conducive to dermal toxicity studies since the skin is completely permeable; all gas exchange occurs across the skin. The western fence lizard, *Sceloporus occidentalis*, has been used to study the oral toxicity of lead, RDX, TNT, and 2,4-DNT; this species is being promulgated as a viable reptilian toxicity testing system capable of rapid turnover. Importantly, these efforts to develop and promote the use of nontraditional model species for toxicity testing aid the risk assessment process by reducing uncertainty.

*Tools to Facilitate Army Ecological Risk Assessments.* Wildlife Toxicity Assessments (WTAs). An important component of an ERA is an understanding of the toxicity of a compound of interest. The first step in an ERA is called a screening-level ERA and usually involves comparing an estimate of receptor exposure, expressed in mg compound/kg body weight/day to a toxic dose, expressed in the same units. If exposure/toxicity is greater than 1.0, then there exists the potential for adverse effects. The level of compound to which the exposure is compared is called a Toxicity Reference Value (TRV) and is derived in a number of ways from laboratory

toxicity data. These values are essential for screening-level ERAs and, for compounds that are not commonly encountered, can be difficult to obtain. The HERP has developed a methodology for deriving TRVs with a focus on compounds relevant to Army risk assessments; USACHPPM Technical Guide 254 provides a detailed methodology for product WTAs.<sup>8</sup> The WTAs consist of both a toxicity profile component in which toxicity information on a given compound is described and a TRV component where the toxicity data is used to derive the compound-specific TRV. The methods used to derive a TRV are intended to be transparent and easily followed by users of the document. A hierarchical approach for deriving TRVs is employed in which more robust methods are used when ample data is available. A confidence rating is also applied to the TRV based on the amount of information available. An important aspect of WTAs produced by USACHPPM is that they undergo an internal review as well as an external, non-Army review process. This ensures the scientific integrity of the WTA and lends credence to its use in the wider scientific and risk assessment field. Currently, WTAs are completed for compounds such as TNT, RDX, trinitrobenzene (TNB) and others, and a number are in the external review process or currently in progress. This is intended to be an ongoing project with compounds selected for WTAs based on Army need.

**Terrestrial Toxicity Data Base (TTD).** Given that toxicity data, specifically TRVs, are needed to conduct a screening-level ERA, it can be difficult to obtain TRVs since there can be more than one for a given compound. In an effort to facilitate Army risk assessments, the HERP has developed the TTD, which is a database of available TRVs for compounds frequently encountered in Army risk assessments, although non-Army risk assessors can use the database as well. Importantly, the TTD not only provides a source for TRVs from a number of agencies, it also provides a ranking system so that users can choose the best available TRV, based on a number of criteria, such as the method used to derive the TRV, the number of studies used, whether the value is based on chronic data, and a number of others, totaling 12 criteria. The data base will be available for download from the web; the HERP will update and maintain the database.

**Terrestrial Wildlife Exposure Model (TWEM).** The other important aspect to ERAs includes estimating or quantifying exposure of the receptor to the compound of interest. The estimate of exposure is compared to the TRV during the screening-level ERA and, hence, is very important in determining a course of action. Exposure to toxic compounds can occur via the diet, dermal routes, inhalation, or incidental ingestion such as inadvertent soil consumption while foraging. For most cases, the important route of exposure is usually ingestion of contaminated forage items and incidental ingestion

of contaminated substrates. In some cases, animals may consume substrate such as soil to facilitate digestion or to acquire minerals. For the most part, inhalation and dermal routes of exposure are less important than ingestion and also less likely to have acceptable toxicity data. The TWEM was designed to facilitate estimates of exposure for screening-level ERAs. The model generates estimates of exposure for a number of potential receptors by combining data on the ecology of the receptor with contaminant information in a mathematical model. For example, a robin inhabiting a contaminated habitat will be exposed to that contaminant based on its behavior and foraging activities. The model is conservative in that it basically assumes the receptor is staying in the contaminated area, even if that area is smaller than the home range of the organism.

**Spatially Explicit Exposure Model (SEEM).** While TWEM generates a fairly conservative estimate of receptor exposure, the SEEM is more sophisticated in that it generates a distribution of exposures for a population of receptors that moves through the habitat. A population is basically a group of same-species organisms inhabiting a given area. Although the precise definition of a population is a debated topic among ecologists, for the purposes of this article, the above definition will suffice. Historically, exposure estimates have been generated for an individual receptor spending all or most of the time in the contaminated portion of the habitat. In reality, non-sessile organisms move freely and frequently through the environment to forage, mate, attract mates, sleep, drink, establish territories, etc. Hence, to base exposure on the assumption that a receptor is entirely within the contaminated area is an oversimplification. Even though this conservative approach is useful for obtaining a rough idea of the exposure extreme, a more accurate estimate of exposure can be obtained by considering the movement of animals through the landscape. The SEEM is a sophisticated computer model that quantifies exposure for a population by moving a specified number of individuals through the habitat. The basic approach involves dividing the habitat or area of interest into a number of different adjacent grids. Within each grid (representing a portion of the habitat) there is a contaminant concentration and a habitat quality value. A receptor moves from one grid to the next and forages in each grid space. The level of exposure is determined by the amount of contaminant in the grid space and the habitat quality since it is likely that an animal will stay longer and eat more in a habitat it considers to be high quality.

## Summary

Toxicology and ecotoxicology efforts at USACHPPM employ tools of science to better define the existence and extent of toxicological problems in order to eventually help prevent and remediate their adverse effects. Although some tools (models) in ecotoxicology have yet to have the “study” time

that those in the broader discipline have, they are anchored in the fundamentals of toxicology and will become even more established with time. The production of characterization data and risk assessments will hopefully continue to provide policy makers and Army managers with a means to keep both Army personnel and the environment out of harm's way.

The DTOX is not alone in its efforts to provide safe materiel and environments for the Army and relies on its colleagues at USACHPPM for assistance. The USACHPPM shares expertise and data with other investigators as is evident through co-sponsorship of the Toxicology and Risk Assessment Conference, reports and publications, and web-based information. The various professionals at USACHPPM possess the expertise to form the multidisciplinary collaborations necessary to solve the complex problems that are the nature of preventive medicine in today's military environment.

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## Change to the Journal Editorial Board



Sergeant Major Alan E. Graykowski has replaced SGM Peter Junjulas on the Editorial Board, effective 1 Jan 04. Sergeant Major Graykowski is assigned as the Corps Specific Branch Proponent Officer, Enlisted Corps, U.S. Army Medical Command.

# **Longitudinal Health Risk Assessment Program**

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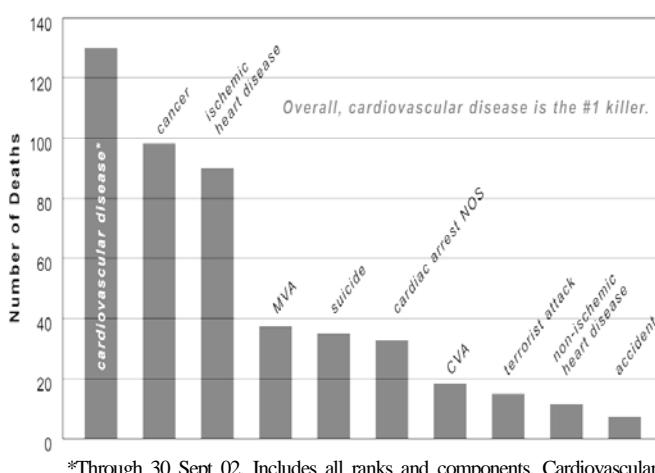
Carlla E. Jones††††

## **Introduction**

The Longitudinal Health Risk Assessment Program (LHRAP) is a pilot program that will use evidence-based screening and risk reduction interventions and tools to decrease morbidity and mortality associated with chronic health risks such as hypertension, hyperlipidemia, obesity, and smoking. The program addresses cardiovascular and cancer risks for active duty Soldiers age 35 and above. The long-term goals of the LHRAP are to: (1) decrease the incidence of preventable chronic diseases and cancer; (2) decrease health care costs associated with preventable chronic diseases and cancer; and (3) create an electronic foundation for longitudinal patient medical records.

## **Background**

Every year, the Army loses Soldiers to preventable chronic diseases such as hypertension and coronary artery disease and to preventable cancers such as breast cancer, cervical cancer, prostate cancer, and colon cancer. Cardiovascular disease, in particular, takes a toll on Soldier health. Cardiovascular disease is the top cause of death among service members over the age of 40 (Figure 1).



*Fig 1. Top 10 causes of death for service members age 40 and above, 1998-2002. (Source: Mortality Surveillance Division, Armed Forces Institute of Pathology.)*

To address the preventable chronic diseases of senior leaders, the Army implemented a program at the U.S. Army War College in 1982. The Army Physical Fitness Research Institute (APFRI) administers the program. The APFRI conducts extensive medical screenings of War College students. Appropriate education and intervention is provided to students based on the results of these screenings. Unfortunately, the program is too intensive in terms of time and resources to be duplicated on an Army-wide scale. Recognizing this, the U.S. Army Surgeon General asked the U.S. Army Center For Health Promotion and Preventive Medicine (USACHPPM) to compare APFRI program components to current medical literature and evidence-based recommendations (such as those provided by the U.S. Preventive Services Task Force) in order to determine the most valuable program components to systematically distribute across the Army.

## **APFRI Evaluation**

The USACHPPM LHRAP team evaluated the APFRI program using the following assumptions:

- *First*, do no harm. Screenings with poor predictive value that might lead to more invasive procedures would be deleted from the APFRI screening protocol. For example, the literature indicates that the treadmill test has a poor predictive value for individuals who do not have symptoms of coronary artery disease. A false positive on the treadmill test can lead to the more invasive thallium stress test or even cardiac catheterization. These procedures pose small but real risks for patients. In addition, using screening tests inappropriately wastes health care dollars.

- *Second*, a screening program must be based on the evidence with a goal toward shifting the risk of the targeted population. The LHRAP is not intended to be a special perk program for senior leaders; the goal of the LHRAP is to decrease the risk of preventable chronic diseases among all Soldiers.

- *Third*, the LHRAP seeks to increase accountability for the health care decisions of patients, providers, commanders, and the medical system. One of the goals of the LHRAP is to

make compliance with regulations such as Army Regulation (AR) 40-501 more visible.<sup>1</sup>

- Fourth, the LHRAP seeks to provide consistent intervention and long-term follow-up as Soldiers move from one installation to another.

With these assumptions in mind, the APFRI program was assessed. All screening procedures were evaluated for sensitivity, specificity, and accuracy using current national evidence-based guidelines and standards. The cost of a particular screening was also considered. The table below details the screenings that will be included in the LHRAP.

Screening	Specifier
Lipid Panel	—
Blood Pressure	—
Obesity Measures (body mass index and waist circumference)	—
Framingham Risk Index	—
Health Risk Appraisal	—
Blood Glucose	Based on Metabolic Risk
C-Reactive Protein*	For those in the Intermediate Cardiac Risk Category
Prostate Specific Antigen	At age 40 for those in the High Risk Prostate Cancer Category; all other age 50
Pap Smear	—
Mammogram	Starting at age 40
Fecal Occult Blood Test	At age 40 for those in the High Risk Colon Cancer Category; all other at age 50 (unless the patient undergoes colonoscopy)
Flexible Sigmoidoscopy/Colonoscopy*	At age 40 for those in High Risk Colon Cancer Category; all other at age 50

\*Not currently an APFRI Program Component

*Table. LHRAP Screenings*

## Needs Assessment

The next step in the development of the LHRAP was to assess the needs of the target population. Initially, the LHRAP was to be targeted to the same population that the APFRI program targeted: Soldiers age 40 and above. This represents 1% to 2% of the total Army population. However, further investigation revealed that ischemic cardiovascular disease, which is one of the most important preventable chronic disease risks in terms of mortality, morbidity, and cost to the Army,

occurs at a much younger age than initially thought. Investigation by the LHRAP team revealed that 19% of deaths from cardiovascular disease occur among Soldiers between ages 35 to 39. This finding increased the size of the target population by more than 50,000 Soldiers and made cost-effective streamlining of the LHRAP essential.

The LHRAP team also assessed the target population for other preventable chronic diseases. Colon cancer, prostate cancer, breast cancer, and cervical cancer were identified as initial targets for the program because the literature indicates there are good screening tests available and that early intervention makes a difference in the outcomes of these diseases.

## LHRAP Design

The program was designed to impact the largest number of Soldiers with the greatest health benefit for the least cost. The LHRAP contains four main components.

*Identification.* The first component of the LHRAP is to identify whether a Soldier is at risk for cardiovascular disease, colon cancer, prostate cancer, breast cancer, or cervical cancer. This identification component requires a recent physical examination. The AR 40-501, paragraph 8-19c(3), states: "All other personnel on active duty will have a periodic examination on record no older than 5 years beginning at age 30." Unfortunately, compliance with this regulation is lackluster. According to the Total Army Personnel Data Base, the breakdown for Soldiers overdue for physical exams is as follows: (1) General Officers: 9%. (2) Field Grade Officers (35% of Colonels): 28%. (3) Warrant Officers: 11%. (4) Senior Noncommissioned Officers: 23%. Therefore, the first component of the LHRAP is to ensure that the members of the target population are in compliance with the physical examination requirements of AR 40-501.

*Electronic Data Capture.* The second component of the LHRAP is electronic data capture of the results of the physical examination and an assessment of risk for preventable cardiovascular disease and cancer. Currently, examination results are placed into a paper chart, and there is no requirement for the clinician who does the examination to make an assessment of risk for preventable cardiovascular disease and cancer. The LHRAP will provide a user-friendly electronic history and physical form for use by clinicians; the form will prompt clinicians to make an assessment of preventable disease risk and make examination results quickly and easily available for reporting, follow-up, and data mining.

*Risk Classification.* The third component of the LHRAP is risk classification. The electronic results of the physical

examination are processed through a series of evidence-based algorithms. These risk stratification algorithms were developed from nationally recognized guidelines and standards. Experts were consulted to tailor these guidelines to the needs of the Army population. The algorithms, along with information from the Composite Health Care System such as pharmacy data and laboratory analysis, are combined to assign each patient a risk classification of high, intermediate, or low risk for each of the five specified diseases.

*Education and Follow-up.* The fourth component of the LHRAP is education and follow-up. Follow-up for cardiovascular disease risk is of particular concern. For example, a 42-year-old male who smokes and has a high total cholesterol and high blood pressure would be classified as high risk for cardiovascular disease. Research indicates that this patient has about a 20% chance of having a cardiac event, such as a heart attack, in the next 10 years if nothing is done to change his risk.<sup>2</sup> In the current paper-based physical examination system, individuals like this may be lost to follow-up. This might happen for many reasons including lack of motivation for change on the part of the patient who is still asymptomatic and feels healthy, transfer of the patient to a different post, transfer of the patient's doctor, or a failure of the patient's doctor to understand and communicate the risk to the patient within a hurried clinical visit. Patients in the high risk category need close follow-up. With its computer-captured history and physical, evidence-based risk classification and provider treatment prompts, and computerized follow-up capabilities, the LHRAP will ensure that this type of patient receives appropriate treatment and follow-up. Luckily, within the Army, the number of people in the high risk population is relatively small. Therefore, individualized case management of these patients could make a difference in the life of the individual Soldier and reduce the burden on the medical system. However, intensive intervention and follow-up that focuses just on the high risk group would only produce a limited shift in the population's event burden, so the LHRAP addresses the needs of the intermediate and low risk groups as well.

Intermediate-risk patients have a 10% to 20% chance of having a cardiac event in 10 years.<sup>2</sup> This relatively large group of Soldiers has significant risk factors for cardiovascular disease such as isolated or mild high cholesterol, high blood pressure, and smoking, but enjoy good overall health. Because of the size of the population, the majority of the "payoff" of risk reduction efforts is with these Soldiers; however, this group's size also mandates the use of an efficient approach to risk reduction. Therefore, it was determined that intermediate-risk patients will receive immediate intervention and education with follow-up to reassess their risk status in 1 year.

Low risk patients have less than a 10% risk of a cardiac

event in 10 years.<sup>2</sup> Low cost education interventions are the only feasible approach for the low risk group. According to AR 40-501, follow-up to reassess their risk status is recommended in 5 years. Figure 2 shows the LHRAP Process.

### **Longitudinal Health Risk Manager**

Patient identification, electronic data capture, risk classification, education, and follow-up are the core components of the LHRAP. However, a manager is needed to combine these components into a workable program. A nurse (or team of nurses, depending on the size of the installation) will be specially trained to integrate all the available information from the LHRAP process and will serve as the Longitudinal Health Risk Manager (LHRM). The LHRM will perform a number of functions in order to achieve the goal of information integration and improved patient care.

First of all, the LHRM will assist in the coordination of intervention delivery for identified treatment needs. For example, in the current system, a patient with an abnormal lipid profile may not receive a referral to nutrition counseling because there is no way to "red flag" that finding. The LHRM will ensure that appropriate interventions are provided and facilitate access to care. Another responsibility of the LHRM is to perform chart reviews on members of the target population who are up-to-date on their physicals but do not yet have a risk classification.

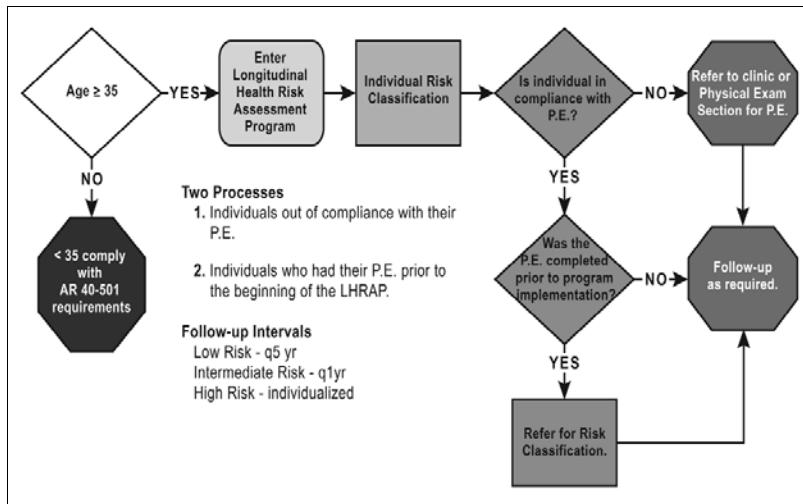
The LHRM will also provide tracking and feedback from a corporate perspective. For example, the LHRM can: (1) assist clinical providers in complying with clinical practice guidelines (CPGs); (2) provide hospital commanders with information on trends in care (stratified by provider panel); (3) provide unit commanders with analysis of the risk classification of their units; and (4) track compliance with program recommendations.

Figure 3 presents an overview of the LHRM position as integrated into the Primary Care Team.

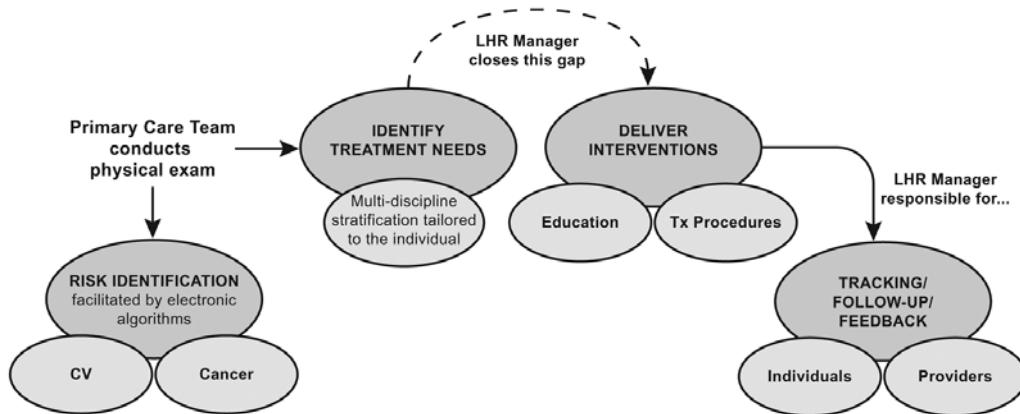
### **LHRAP Pilot and Replication**

The LHRAP is slated to begin a pilot study at Fort Meade, MD, in fiscal year 2004. The goals of the pilot project include:

- Analysis of current patient flow processes and development of a new and/or improved process to facilitate the LHRAP (business process re-engineering).
- Documentation of methodologies to garner command support for the LHRAP.
- Documentation of methodologies to gain provider and



*Fig 2. The LHRAP process.*



*Fig 3. Overview of the LHR Manager position as integrated into the Primary Care Team.*

patient acceptance of this shift in focus regarding delivery of care.

- Assurance that the main project components function as intended.
- Data gathering to support proliferation of the program. Two large troop installations will be selected as LHRAP replication sites later in fiscal year 2004.

### **Benefits of the LHRAP**

The primary goals of the LHRAP are to identify intermediate- and high-risk Soldiers and, through the use of education and follow-up, decrease their risk for preventable chronic diseases. The long-term benefits of the LHRAP, therefore, are expected to include decreased morbidity and

mortality and decreased health care costs. These long-term benefits are anticipated to occur, at a minimum, 5 to 10 years after the implementation of the LHRAP.

However, in addition to the long-term benefits, the LHRAP is also expected to produce many other short- and intermediate-term benefits. The short-term benefits of the LHRAP are expected to include:

- Improved compliance with physical examination requirements and CPGs.
- Increased patient awareness of chronic health risks.
- Increased corporate awareness of the level of risk in the population for the targeted diseases. This should result in better resource allocation.

- Identification of units with high-levels of risk for the diseases of interest. These units can be targeted for education and other interventions.

- Identification of training opportunities for providers.

The intermediate-term benefits of the LHRAP are expected to include:

- Decreases in targeted parameters such as blood pressure, cholesterol, body mass index smoking, Framingham risk, etc.
- Stabilization or decrease in assigned risk classification as an individual is followed over time (Soldier in high risk category shifted to intermediate or low risk as a result of

intervention and follow-up).

- Decrease in aggregate population risk (the percent of Soldiers identified as high or intermediate risk should decrease over time).

- Increase in patients, health care providers, hospital commanders, and unit commanders who are actively engaged in monitoring and reducing chronic health risks.

- Provision of an electronic foundation for longitudinal patient medical records.

Figure 4 presents an overview of the proximal and distal outcomes of the LHRAP.

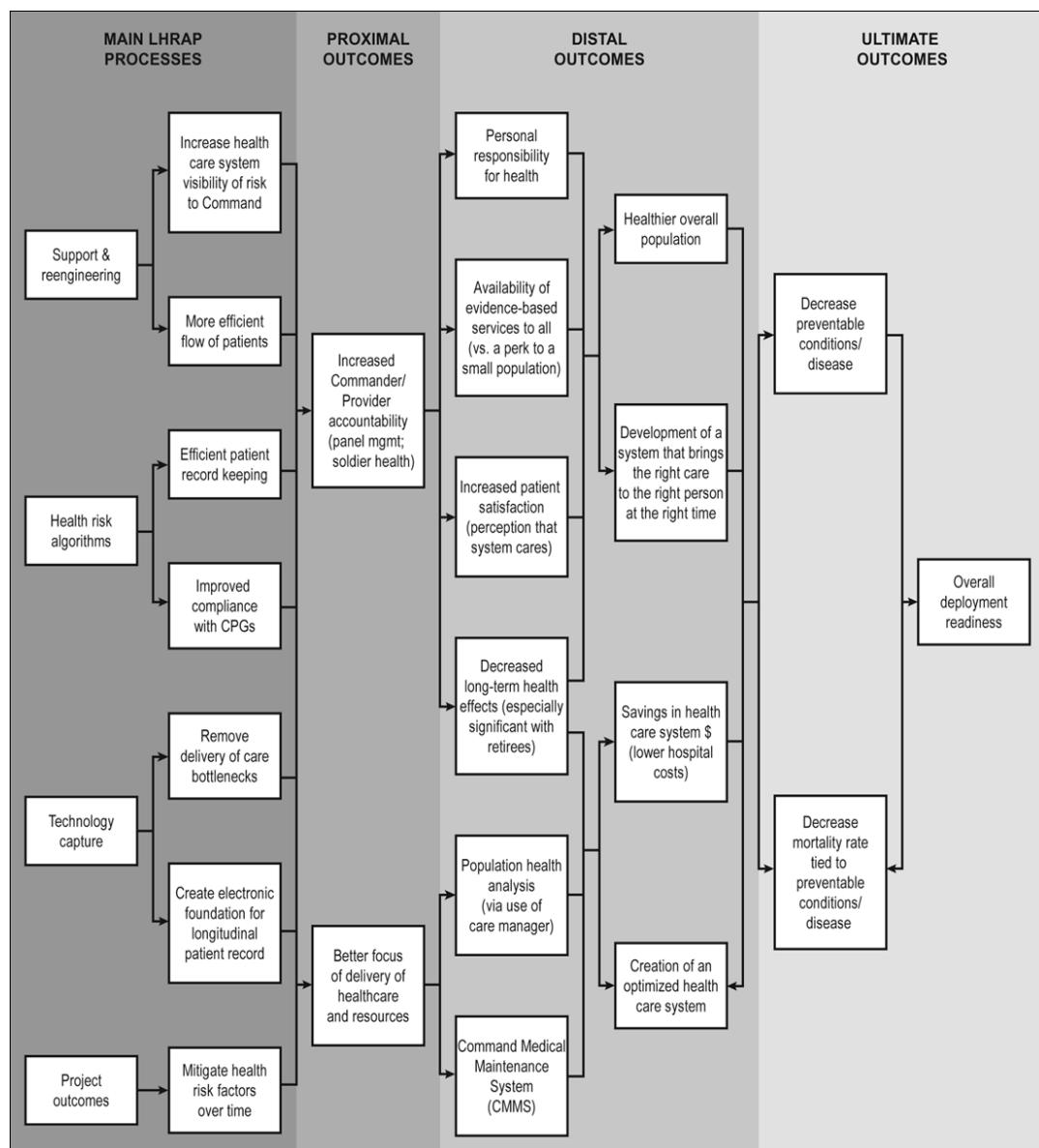


Fig 4. LHRAP proximal and distal outcomes.

## **Conclusion**

The long-range vision is that the LHRAP will ultimately result in decreased incidence of preventable chronic diseases, decreased morbidity and mortality rates, and lower health care costs. There is the potential for significantly increased health and wellness of senior active duty Soldiers and Army retirees. The use of evidence-based screening and the risk reduction interventions of the LHRAP has the added benefit of improving the readiness and deployability of active duty Soldiers.

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# ***Making Better Decisions: Using GIS at USACHPPM***

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## **Introduction**

The U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) provides worldwide scientific expertise and services in clinical and field preventive medicine, environmental and occupational health, health promotion and wellness, epidemiology and disease surveillance, toxicology, and related laboratory sciences. It supports readiness by keeping Soldiers fit to fight, while also promoting wellness among their families and the Federal civilian work force. Professional disciplines represented at USACHPPM include chemists, physicists, engineers, physicians, optometrists, epidemiologists, audiologists, nurses, industrial hygienists, toxicologists, entomologists, and many others as well as sub-specialties within these professions. Many of the services these professionals perform for their customers focus on health issues that are spatial in nature. Noise levels near aircraft runways, concentrations of disease-carrying arthropods, and ground-water contamination near artillery ranges are issues that share a spatial component and affect the health of the Department of Defense (DOD) and surrounding civilian populations. The Geographic Information System (GIS) is a tool that decision makers at USACHPPM have been using for over a decade for these and other spatial issues.

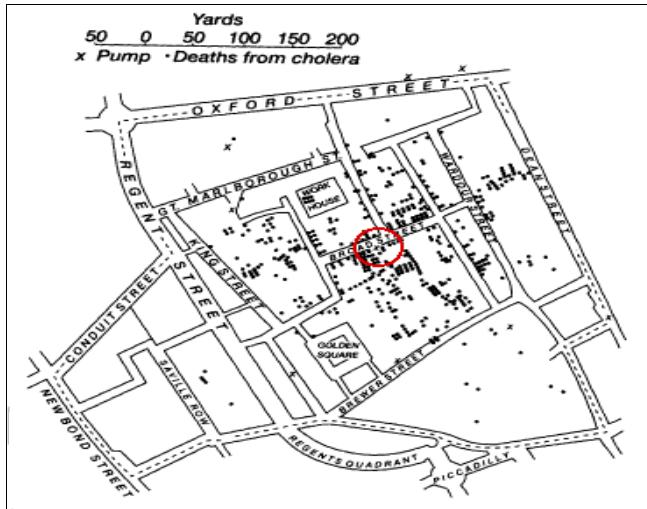
Predating the current conception of the GIS, paper maps were used as a tool to combat the 1854 cholera epidemic in London. Doctor John Snow, a London physician now regarded as a pioneer in epidemiology, was interested in how cholera was transmitted. He plotted cholera cases and well locations on a street map of London, identifying a clustering of cases near a particular water pump along Broad Street (Figure 1). Doctor Snow convinced city officials that the well was contaminated and the Broad Street pump was removed. Using geography and a map as his presentation medium, Snow successfully illustrated a higher death rate from cholera associated with the Broad Street pump versus other well locations.

## **Background**

A modern GIS is a computer-based system that stores and processes digital map information or layers. A GIS layer contains data from a common theme (roads, sampling locations,

soil types) that is referenced to a location on earth via a common coordinate system. Layers contain features, which in most GISs are points, lines, or polygons that represent real-world objects or phenomena in space. These abstractions of real-world features contain descriptive information (attributes) that allow querying of the data, much like a database. In addition to attribute queries, spatial queries are a critical dimension in GIS. Since every layer is referenced to a coordinate system, features in layers can be searched based upon proximity to other features. Additionally, overlaying existing layers of data can create new data layers. Also, mathematical operations can be performed on the data by treating the attributes of GIS layers as variables in an equation. With these principles, the GIS enables the answering of geographic questions and reveals relationships, patterns, or trends. The GIS is also an effective communication tool for conveying synthesized spatial and temporal information in lieu of a lengthy report.<sup>1</sup> The GIS can incorporate data derived from numerous sources. Users can input data from Global Positioning System (GPS) devices, chemical release models, analytical results databases, scanned or digitized maps (similar to Computer-Aided Drafting [CAD]), or satellite imagery to name a few. Creating data yourself or contracting out for data creation is costly. More times than not, it makes sense to use pre-existing data sources which may mean gaining organizational access to the data. Data needed for a particular GIS project may be stored at the local, state, or Federal Government agency level. Overcoming territorial ownership and sharing data is important to the taxpayer for fiscal reasons, so that redundant data are not created. It is estimated that of the \$4 billion dollars spent by Federal agencies on data collection, nearly half of those dollars could be saved. Sharing of data also makes sense for safety reasons in this era of Homeland Security as agencies plan for contingencies. Often Government managers and decision makers think there is a “magic box” for gathering GIS data. However, a GIS analyst usually must go to multiple Government and commercial sources in order to complete a project. One Federal initiative to address this issue is the Geospatial One-Stop (<http://www.geo-one-stop.gov>). As a part of President Bush’s Electronic-Government (E-Government) agenda, this information portal seeks to locate maps and related data at a single location on the Internet. Data will be contributed by Federal, state, and local agencies. The USACHPPM is also devising a portal to share information at

the enterprise level to address these same issues. Many programs from various disciplines and professionals in various scientific and engineering fields use GIS. Much of the data used by these professionals is baseline data, such as installation boundaries, roads, streams, etc. This data need only be stored once on a network share site, to be accessed many times by other professionals for their specific needs.

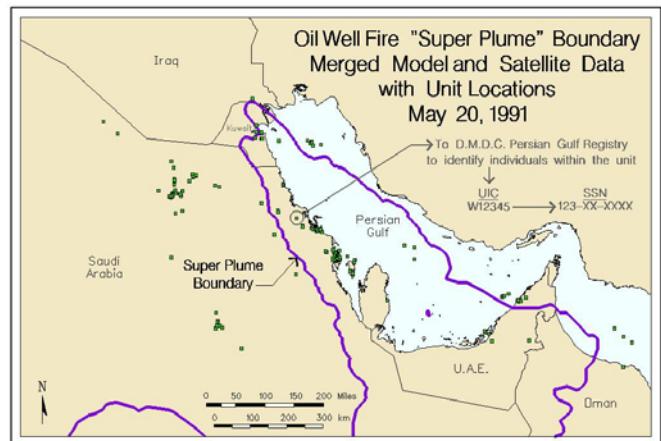


*Fig 1. Dr Snow's London street map showing a clustering of cholera cases near a particular water pump. (Source: The Geographical Journal.)*

Personnel have found it easier than ever to use a GIS. Most software tools now have a graphical user interface with buttons, tools, and help guides to assist the end user. As more and more digital geographic data becomes available, using GIS as a tool may become as routine as using word processing at the workplace; having a basic understanding of geographic principles is beneficial. For instance, data mapped at different scales and coordinate systems need to be reconciled before an analysis can be performed. The Army and the Federal Geographic Data Committee ([www.fgdc.gov](http://www.fgdc.gov)) are determining standards so that data can be used effectively.

*Example One.* One example of how USACHPPM uses GIS involves the study of veterans' environmental exposures and health outcomes from the 1991 Gulf War. By integrating satellite imagery, troop locations, and modeled exposures, the USACHPPM assisted Government, university researchers, and health professionals trying to assess potential relationships between exposures that occurred in the Gulf War and the current health problems reported by veterans. To examine veterans' exposures to the smoke from the 1991 oil well fires, USACHPPM used data from various Government agencies. Specifically, USACHPPM acquired daily satellite images and modeled grid concentrations from the National Oceanic and Atmospheric Administration. The satellite images and modeled grid concentrations that demarcate the oil well fire smoke

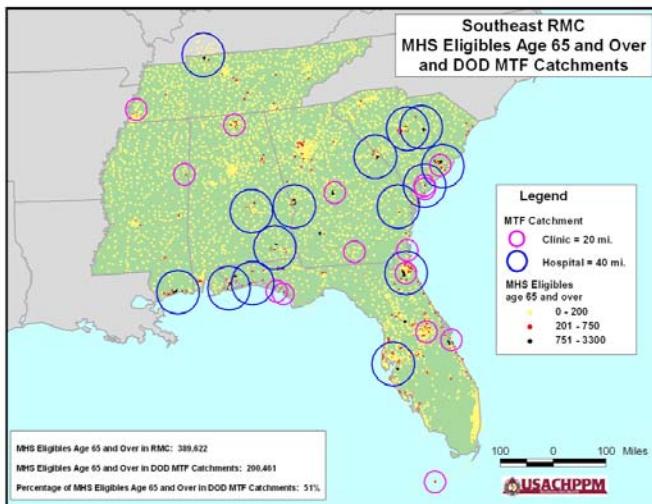
were each digitized, or traced, to create GIS layers for each day of the catastrophe. Troop unit locations were gathered from the U.S. Armed Services Center for Unit Records Research and combined with the Defense Manpower Data Center's Gulf War personnel registry. The resulting troop unit and personnel data base can now display a virtual layer of unit locations and personnel throughout the theater (Figure 2). By integrating the modeled exposure and troop unit data layers, the USACHPPM aided the Office of the Special Assistant for Gulf War Illnesses with value-added information about troop unit locations in relation to oil well fire smoke and what the troops' potential exposures may have been. This information was critical to the Army's investigation of incidents and circumstances during the war that might be related to veterans' symptoms.



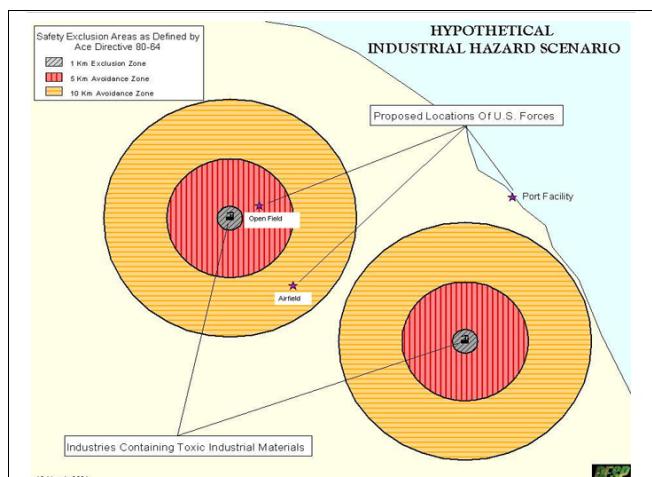
*Fig 2. GIS layer of unit locations and personnel throughout the theater during the 1991 Gulf War.*

*Example Two.* The Army Office of The Surgeon General (OTSG) captures patient encounters in a database by the patient's treatment zip code. The OTSG wanted to tabulate, by geographic market area, the number of patients within close proximity to the nearest Army military treatment facility (MTF). If patients were not within an MTF area of service, OTSG wanted to know what the nearest metropolitan area was for those patients. This type of analysis was not possible with a traditional database. With GIS, MTF treatment areas were created by buffering – creating a radial area around a point. Next, the number of Military Health System (MHS) eligibles within those MTF treatment areas could be spatially queried, along with how many eligibles were outside of MTF treatment areas. Then, populous urban centers without MTFs were buffered and overlaid with MHS eligibles to quantify and rank underserved MHS markets. Now, OTSG could visualize this information on a map (Figure 3) and view in tabular format the geographic areas where Army beneficiaries sought treatment outside Army MTFs. This information was then used to justify creating partnerships with health care networks outside existing MTF areas.

*Example Three.* The Deployment Environmental Surveillance Program at USACHPPM can use GIS to recommend alternate locations for base camps during deployments according to Allied Command Europe (ACE) Directive 80-64.<sup>2</sup> This directive seeks to minimize placement of troops near toxic industrial chemicals (TICs) by defining safety zones around TICs. Often in the past, these base camps were located in close proximity to industrial facilities due to security and logistical issues. The GIS can help find an alternate location for base camps that meets the exclusionary requirements stated in the ACE Directive (Figure 4). Planners also have the ability to assess the potential environmental health risk associated with these facilities. Using a GIS linked with data provided by the intelligence community, the planner can use mathematical dispersion models and meteorological information to calculate potential exposure levels to the troops in a real-time manner.



*Fig 3. Geographic areas where Army beneficiaries sought treatment outside Army MTFs.*



*Fig 4. Using GIS to recommend alternate locations for base camps during deployments.*

*Example Four.* The USACHPPM Range Studies Team visits DOD installations to assess possible environmental contamination and health risks that could result from munitions residue at firing ranges. These investigations require extensive sampling of various environmental media including ground water, soil, surface water, and vegetation. The team relies heavily on GIS to develop and implement defensible sampling strategies of these media and to present the results of the investigation after completion. Prior to using GIS, scientists used paper maps and pencils to devise plans and determine sample points. Sampling locations were often located in the field with stakes and hand-held measuring tapes. This approach was particularly unsuitable to assess the large impact areas that typically are used for training. To meet these challenges, USACHPPM was one of the first to apply the capabilities of GIS to environmental assessments. Instead of paper grids and wooden stakes, digital grids are constructed. Sample points within those grids are randomly selected using a computer. The coordinates for those sample points are determined and entered into GPS hand-held units. The GPS consists of a series of orbiting satellites that triangulate a location on the earth with a hand-held receiver on the ground. The preprogrammed GPS units are used to navigate to the sample locations. This integration of GPS and GIS enables navigation to predetermined random sample points that are situated throughout large areas of difficult terrain. The implementation of a random sample strategy enables a scientifically defensible, statistical approach to evaluating the data. The GIS applications do not stop with the development of the sample plan. After the samples are collected, a variety of GIS data layers are also used to present the data and illustrate the report. These GIS layers enable more powerful graphics to display the results of the sampling. These layers include digitized aerial photos, satellite images, road networks, firing range boundaries, and topography, to name a few. With GPS used in conjunction with GIS, scientists can make better decisions on where to sample before going out to the field. After collecting the field data, scientists can more accurately interpret the data and more concisely present those interpretations in their reports.

*Example Five.* The Environmental Noise Program at USACHPPM provides a number of services to both the U.S. Army and Army National Guard as well as other branches of DOD in which GIS plays an integral role. Tanks, artillery, small arms weapons and helicopters, all standard equipment for the Army, produce unique sounds in the course of training and maneuver operations. Increasing population and urbanization have lead to encroachment on military installations, thereby compounding the problems of environmental noise. The loud sounds generated during training often penetrate into nearby communities, which may impact upon the neighboring citizens both day and night.

The Installation Environmental Noise Management Plan (IENMP) is the main component of noise abatement used by the Army to find common ground with neighboring communities through effective planning. The IENMP is an installation-specific study of the existing and future noise environment developed to aid military and civilian officials and planners in creating compatible land-use plans and policies that will be beneficial for both the civilian sector and the installation's mission requirements. The IENMP contains noise zone maps that are essentially the technical focus of the plan. Noise zone maps consist of noise contours, which are created using computer models specific to the type of activity. This means different models are used for different noise sources (aircraft, small arms weapons, large-caliber weapons, etc). The models create contours by querying large databases against new data input and a number of mathematical algorithms to predict noise at certain levels or zones. These contours can then be imported into a GIS and used as overlays on other data layers to create noise zone maps. A noise zone map serves as an excellent planning tool, which may distinguish areas of incompatibility between the noise environment and local communities, on-post family housing, deployed soldiers in the field or protected wildlife habitat. Acreage analysis within a particular noise zone or noise complaint validation can also be performed using the noise contour and a GIS. Before the advent of GIS, noise contour overlays had to be plotted on paper maps by hand, using grid coordinates which was extremely time-consuming. Thus, what may have taken a day or more to plot now can be imported in a matter of minutes using GIS.

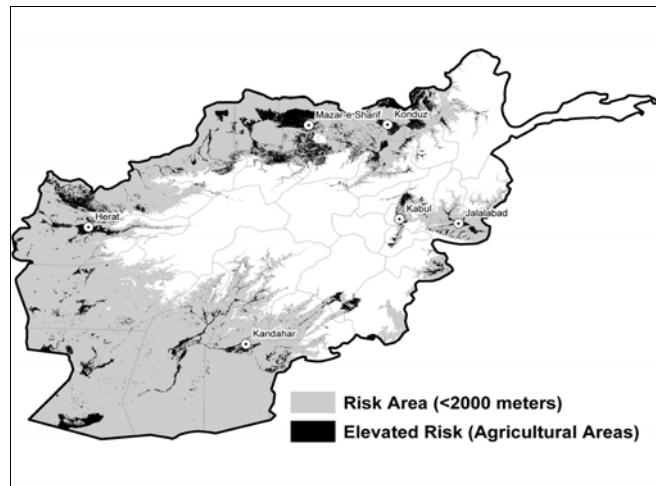
### **GIS and the Entomology Sciences Program (ESP)**

The mission of ESP is to reduce the risks to the Soldier, military community, and Government property from exposure to pests and pesticides, maximizing the ability of Department of the Army preventive medicine units to protect the Soldier from the health threat posed by vector-borne disease and medically important pests and to minimize the adverse effects of pesticides. The ESP uses GIS technology to assess the potential risks of vector-borne diseases, to provide state-of-the-art consultation for implementing Integrated Pest Management (IPM) practices, and to evaluate the presence of potentially harmful pesticide residues in the environment.

**Vector-borne Disease Risk Maps.** Historically, vector-borne diseases have caused significant numbers of disease and nonbattle injury casualties in our deployed forces. These diseases vary significantly from place to place, even within a region or country. The ESP has incorporated the use of GIS technology to assess the potential of vector-borne disease. The risk maps produced have become an important tool in accomplishing USACHPPM's mission to protect deployed forces. The GIS layers from remote sensed data (satellite

imagery) provide the capability to produce a risk map prior to deployment, without "on the ground" data.

For example, two risk factors for malaria in Afghanistan can be displayed as GIS layers to produce a risk map (Figure 5). Malaria is endemic throughout Afghanistan at altitudes below 2000 meters. A layer showing this elevation and lower altitudes was produced using digital terrain elevation data imagery. Also, vector mosquito breeding is associated with agricultural irrigation practices. A layer showing the distribution of agricultural areas was produced using GeoCover™ (Earth Satellite Corporation, Rockville, MD) land cover imagery. The Afghanistan malaria risk map was produced from these two GIS layers. This risk map is an important component of the Entomological Operational Risk Assessment which is used by field commanders to identify and visualize vector-borne disease risks facing troops during Operation Enduring Freedom.

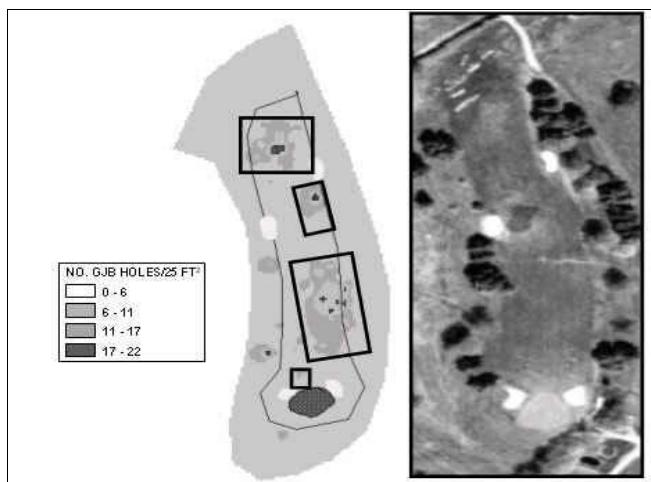


*Fig 5. Afghanistan malaria risk map.*

**Pest Density Distribution Maps.** Pest management on golf courses often requires significant use of pesticides and an ever-increasing annual expenditure for labor. Military golf course superintendents practice the concepts of IPM in order to achieve long-term management of turf pests. The IPM involves the coordinated use of pest and environmental information with available pest control methods. The goal is to prevent unacceptable levels of pest damage by the most economical means and with the least possible hazard to people, property, and the environment. Critical to the success of any golf course IPM program is the ability to accurately map the location of pest infestations, as well as topographic features or agronomic practices that may influence the timing, intensity, or location of turf pests. The ESP is working to put the power of GIS into the hands of the military golf course superintendents, enabling them to collect, store, carry, display, and coordinate pest and environmental information. The ESP has demonstrated to superintendents that this information can be used to precisely

target remedial activities, resulting in significant savings in pesticide outlays and labor costs.

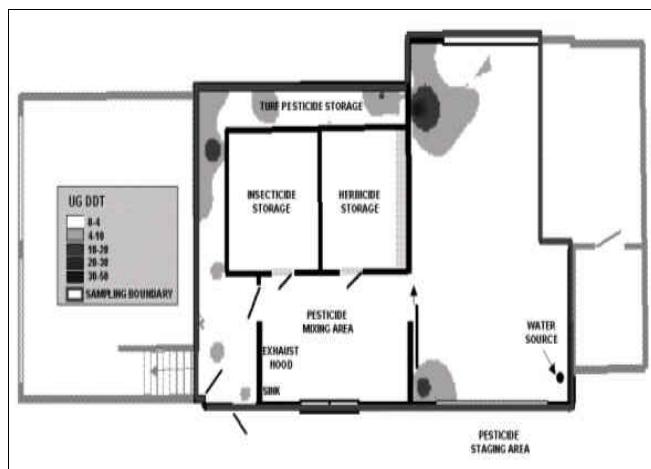
The ESP, in partnership with the Strategic Environmental Research and Development Program, demonstrated the utility of an ArcView™ (Environmental Systems Research Institute, Redlands, CA) GIS platform for field data collection and visualization of an infestation of green June beetle (GJB) larvae at Ruggles Golf Course, Aberdeen Proving Ground, MD. The ESP used Geostatistical Spatial Analysis software developed by the Agricultural Research Service of the U.S. Department of Agriculture, which was supported by funding from the U.S. Army Environmental Center. As depicted in Figure 6, with a high resolution, georeferenced aerial photograph as a base map, concentrations of GJB larvae that exceeded treatment thresholds were recorded, along with the fairway-rough interface, sand traps, sprinkler heads, and fairway distance markers, using a hand-held GPS unit interfaced with a pocket personal computer. Geostatistical and graphics tools were used to create additional GIS layers in order to produce a map that served as a guide for the precision targeting (boxed areas of fairway map) of a pesticide application to control the GJB larvae. By targeting the areas to be treated, rather than a broadcast application of the entire fairway, the amount of pesticide used was greatly reduced. A significant cost savings in material and labor resulted without sacrificing efficacy of control. An additional benefit included the potential for reduced worker and golfer exposure to pesticide residues.



*Fig 6. Aerial photograph and insect density map of golf course fairway.*

**Pesticide Residue Distribution Maps.** The ESP has also demonstrated the utility of an ArcView™ GIS platform for visualizations of pesticide residue distribution inside structures. This innovative method of evaluation of potentially harmful pesticide residues can be used to produce maps that permit remedial actions to be accomplished by the most effective and economical means.

For example, in a decommissioned and decontaminated pesticide storage and handling facility, airborne dichloro diphenyl trichloroethane (DDT) residues represented a health hazard to the new building occupants. The source of these residues was unknown. As depicted in Figure 7, with an architectural blueprint as a base map, concentrations of DDT residues detected in wipe samples collected in a grid pattern inside the building were recorded. Geostatistical and graphics tools were used to create additional GIS layers in order to produce a map that showed that DDT residues were concentrated on surfaces separate from former pesticide storage or mixing areas. This map served as a guide for the application of surface sealants that eliminated the presence of detectable airborne DDT residues inside this structure.



*Fig 7. Map of pesticide residue distribution inside a converted pest control facility.*

### Using GIS for Water Supply Management

The Water Supply Management Program (WSMP) within USACHPPM is dedicated to the production and delivery of safe drinking water to Army installations, field units, and other major Army commands worldwide. To meet this challenge, personnel must stay abreast of technological advances that not only create a better end product for the customer, but do so in an efficient, cost-effective manner. The GIS technology meets these challenges and is rapidly becoming an integral tool for drinking water engineers.

Much of the work conducted by water engineers is spatially oriented. Whether modeling water flow within distribution systems, locating potential contamination sources in proximity to drinking water wells, or assessing water treatment plants for security vulnerabilities, graphical display through GIS is integral to decision making and subsequent information conveyance. Water industry maps have evolved from paper hand drawings to computer-generated CAD drawings. With the emergence of GIS, previous output (for example, hand-drawn,

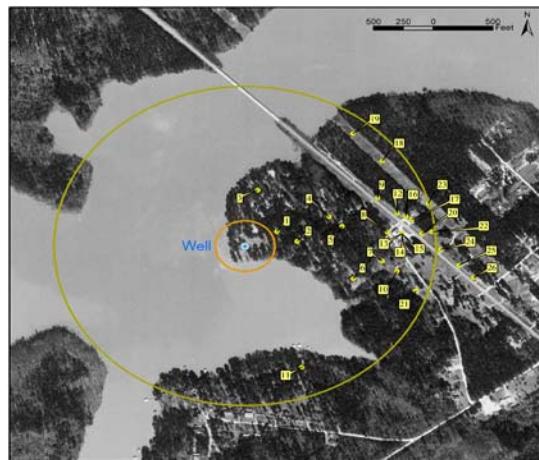
CAD, MicroStation® [Bentley Systems, Inc, Exton, PA], modeling, photographs) could all be integrated into a single platform. This created a powerful tool for making decisions.

Several Federally mandated water industry requirement deadlines are approaching, one of which is the submission of Source Water Assessment Plans (SWAPs). Public water systems using wells as water sources submit Wellhead Protection Plans (WHPPs) to fulfill the SWAP requirement. An example of how the water engineer relies on GIS is demonstrated in these plans. The WHPP investigates drinking water well surroundings for potential pollution sources (PPSs) and determines how susceptible the well is to contamination from each source. Sources of pollution include any water-quality-degrading substance or activity producing such substance that could migrate into the area of the aquifer from which the well draws water, termed the well's zone of influence. Examples of PPSs include septic systems, aboveground/underground storage tanks, landfills, and many business/industrial activities.

Personnel within USACHPPM's WSMP incorporated GPS data, aerial photographs, MicroStation® drawings, and other relevant data into GIS software to complete a WHPP for the Savannah District U.S. Army Corps of Engineers. To initiate the WHPP, a circle representing the well's zone of influence during pumping was determined based on well pumping rate. With this information, WSMP personnel conducted a field survey, and, using GPS, recorded the geographic coordinates of all PPSs within this zone. Combining PPS locations with other data layers, such as aerial photographs, topography maps, and roads, resulted in a graphical representation for determining well susceptibility to contamination. Using data layers of subsurface properties near the well, the factors affecting migration of potential contamination towards the well could be determined. By combining this information, an initial determination of well susceptibility to an individual pollution source could begin.

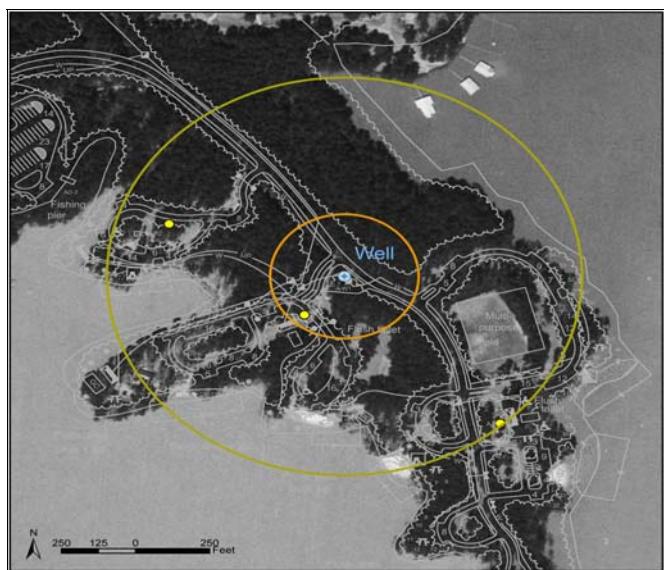
The likelihood of a released contaminant reaching the well was based on distance from the well. Distance ranges were grouped into management zones represented by varying size circles around the well based on well pumping rate and intrinsic aquifer properties. Graphically displaying these zones, along with PPS location, enabled visual analysis of well susceptibility. As opposed to viewing tabular results of PPS distance from the well, graphically displaying locations on aerial photographs not only conveyed distance information, but also showed ordinal and cultural information and provided an accuracy check on PPS coordinates collected during surveying. As an additional backup to the field survey, using high quality aerial photographs would likely reveal any PPSs that may have been missed during the site visit. Obtaining historical aerial photographs could also

reveal past activities that may be considered potential sources of pollution. Figure 8 displays the results of a PPS survey, showing the location of the well (center of management zone circles) and adjacent PPSs. Labeling or reference numbering each PPS allowed for easy identification of the potential source.



*Fig 8. Aerial photograph showing well and PPS locations, and wellhead protection management zones.*

In certain instances it may be unfeasible to collect PPS coordinates by visiting each location. Budget limitations, time restrictions, or PPSs located on private property may require the use of GIS data to virtually survey the well surroundings for PPSs. With adequate data layers, which may include annotated business and industry layers, utility, road and railroad layers, and agriculture and aerial photograph layers, a GIS-based PPS survey may be possible. Figure 9 shows an aerial photograph overlain by well and PPS locations, along with additional site



*Fig 9. Image displaying overlay of output from multiple programs.*

information. Although personal site visits may be the best way to ensure accurate data collection, in many instances obtaining the necessary data layers from credible sources can eliminate the need for onsite surveying. In areas with rapidly changing business and industrial activities, combining historical data layers may be the only way to track potential sources of pollution. Once aware of past occupancies, the water engineer may want to tailor water quality monitoring to test for specific types of contamination that the present survey may not have revealed.

To successfully integrate GIS into water supply projects, three key elements must be present. The data must be accurate, constantly updated, and readily available. Whether the engineer personally inputs data, gathers data from outside sources, or uses model output, an accurate representation of reality is critical.

Advances in GIS are rapid, and the water industry has embraced the change to GIS-based software. By staying up-to-date with emerging technologies such as GIS, the water engineer and scientist is able to efficiently and cost-effectively supply safe drinking water to customers.

## Summary

With the proper ingredients of relevant data, computer software, and trained personnel, GIS has become more than just a graphical presentation tool, it has become an embedded function at USACHPPM. Its value is the integration of various

natural/human-made GIS data layer abstractions and USACHPPM-derived data combined with analysis from our wide array of technical experts. This gives decision makers a clearer picture of the spatial phenomena in question and enables them to make their recommendations. Producing meaningful results that protect the health of the Army, DOD, and their neighboring civilian communities is the ultimate goal of using this technology at USACHPPM.

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# The U.S. Army's HHA Program: Past, Present, and Future

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## Introduction

The Health Hazard Assessment (HHA) Program was established by the U.S. Army Surgeon General to eliminate or control health hazards in the lifecycle management of weapons, equipment, clothing, training devices, and materiel systems and to integrate human health and performance criteria into these areas. The formation of the HHA Program is a product of the Army's effort to eliminate health hazards from materiel systems.

The HHA Program represents one of the seven domains of Manpower and Personnel Integration (MANPRINT). The MANPRINT is an Army Human Systems Integration Program that focuses on the integration of Soldier considerations into the system acquisition process to reduce lifecycle costs, enhance Soldier-system design, and optimize total system performance. The MANPRINT domains consist of HHA, Training, System Safety, Soldier Survivability, Manpower, Personnel, and Human Factors Engineering (Figure 1).<sup>1</sup>

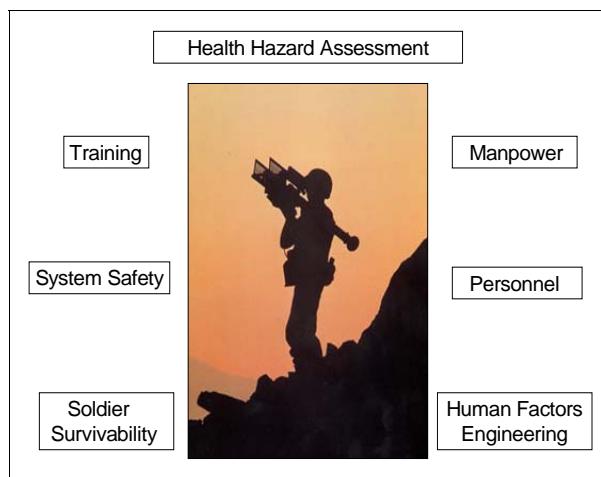


Fig 1. MANPRINT domains.

## Past

Health hazards associated with the use of military items have been a topic of discussion among leaders since the birth of our great Nation when the first surgeon general advised General

George Washington on the outcome of hearing loss among cannoneers as well as diseases in military hospitals and camps.<sup>2</sup> The process of identifying adverse human health effects and performance decrements as a result of exposure to military items has flourished significantly since the 1770s.

As a result of blast overpressure health hazards associated with firing the M198, 155 mm Towed Howitzer, the Army Leadership recognized the need to have a formalized process to address potential health hazards as early as possible in the Materiel Acquisition Decision Process (MADP).<sup>3</sup> The Army Surgeon General (TSG) responded to that recognition in 1981 by establishing the HHA Program to evaluate the potential health effects of operating military weapon systems. In 1983, the Department of the Army published Army Regulation 40-10, *Health Hazard Assessment Program in Support of the Army Materiel Acquisition Decision Process*, and identified TSG as the proponent. In 1995, TSG designated the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) as the Army Lead Agent.

## Present

**Objectives.** The primary objective of the HHA Program is to identify and eliminate or control nine categories of health hazards (acoustical energy, biological substances, chemical substances, radiation energy, shock, trauma, vibration, temperature extremes, and oxygen deficiency) associated with the lifecycle management of weapons, equipment, clothing, training devices, and materiel systems (Figure 2). Specific objectives that support the primary objective are:

- To preserve and protect the health of the individual Soldier and other personnel.
- To reduce degradation of the Soldier's performance and the system's effectiveness.
- To enhance the original system design so that retrofits needed to eliminate or control health hazards are reduced.
- To reduce readiness deficiencies that are attributable to health hazards, which cause training or operational restrictions.

- To reduce personnel compensation claims by eliminating or reducing injury or illness caused by health hazards associated with the use of Army systems.

- To reduce the health hazards due to the potential environmental contamination with the use of Army systems.<sup>4</sup>



Fig 2. Health hazard categories addressed by the HHA Program.

These objectives are managed by an HHA Program Staff consisting of a budget analyst, an administrative assistant, five project officers, and a program manager. Remarkably, the HHA Program has produced over 2000 Health Hazard Assessment Reports (HHARs) since 1981.

Achieving the objectives listed above is best accomplished by being involved as early as possible in the MADP. Proactive acquisition involvement by the HHA Program begins with MANPRINT representation on the U.S. Army Training and Doctrine Command (TRADOC) integrated concept teams. Having representation on integrated concept teams provides the HHA Program the opportunity to emphasize the importance of properly addressing health-related issues and lessons learned in requirements documents being generated by the combat developer.

As system capabilities transition from concepts to materiel solutions, an acquisition program manager is assigned. During this phase of development, the HHA Program provides support to the program manager's integrated product team. This provides another opportunity for the HHA Program to ensure potential health hazards are identified, tracked, and adequately addressed with the ultimate goal of eliminating health hazards by design.

**Process.** Program managers are required to identify and evaluate system safety and health hazards, define risk levels, and establish a program that manages the probability and severity of all hazards associated with the development, use, and disposal of the item they are managing.<sup>5</sup> The HHAR is the product of the HHA process and assists the program manager's total risk management effort by containing the identification and health risk assessment of health hazards associated with the item.

The process of requesting HHA Program services begins when the materiel developer submits a memorandum requesting an HHAR through the U.S. Army Materiel Command (AMC) Surgeon to the Commander, USACHPPM, ATTN MCHB-TS-OHH. If the AMC Surgeon's Office determines there are no potential health hazards associated with the use and maintenance of the item or all of the hazards are adequately controlled, and concurrence is obtained from the USACHPPM HHA Program Manager, a "turnaround" memorandum is prepared which serves as the required

HHAR documentation. If the AMC Surgeon's Office determines there may be a potential health hazard, the HHAR request is forwarded to the USACHPPM's HHA Program Manager who reviews the request and confirms/determines if uncontrolled health hazards are indeed present in the item being procured. If potential health hazards do exist, an HHA project officer is assigned and a matrixed team of subject matter experts is identified to assess the potential health hazards associated with the item (Figure 3).

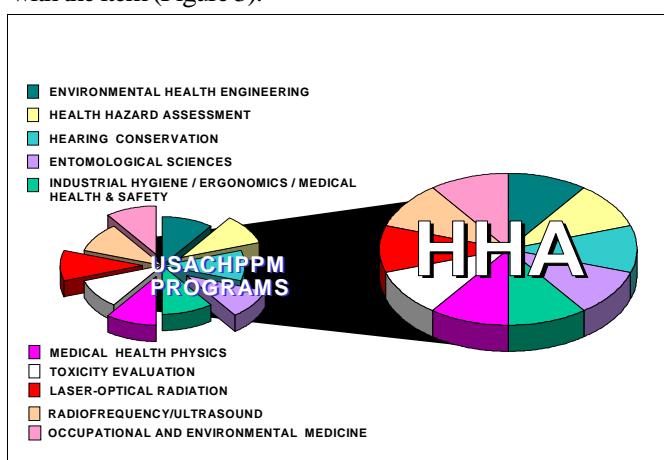


Fig 3. USACHPPM programs that provide matrixed subject matter expert support for HHA.

After obtaining all necessary data from the materiel developer, subject matter experts identify potential health hazards associated with “normal use” to the user or maintainer of the item, and assign a risk assessment code (RAC) (Table 1) for each health hazard based on hazard severity (Table 2) and hazard probability (Table 3).<sup>4</sup> Recommendations to reduce the risk of each potential health hazard are also included in the HHAR as well as a residual RAC based on implementation of the HHAR’s recommendation(s).<sup>6</sup> Additionally, the medical cost avoidance of implementing the HHAR recommendations is calculated using the HHA Medical Cost Avoidance Model (MCAM) developed in 1997. Cost avoidance is determined based on the cumulative risk reduction realized by implementing the proposed recommendations. If the recommendations to control or eliminate the risk are not adopted by the item’s program manager, the risk level may be “accepted” by the appropriate risk decision authority and no medical cost avoidance is realized. As the item’s design matures or engineering change proposals are adopted, the item’s program manager will request updated HHARs through the same process described above. The HHA Program will then issue a revised assessment with recalculated medical cost avoidance based on the risk reduction achieved by adopting the proposed recommendations.

While the HHA MCAM has been well received in both the medical and acquisition community as a valid means to quantify cost savings associated with controlling health hazards, the HHA Program has recently launched an effort to improve the model’s precision. Recent access to Department of Defense (DOD)-wide medical surveillance data will allow the HHA Program to improve upon the current version of the MCAM and incorporate this revised model into the HHAR process. For more information on the improvements currently underway at the HHA Program office, see the Future section below.

		Hazard Probability				
Hazard Severity		A	B	C	D	E
	I	1	1	1	2	3
II	1	1	2	3	4	
III	2	3	3	4	5	
IV	3	4	5	5	5	

Table 1. Risk Assessment Code Matrix Used by the HHA Program to Identify the Risk Level Associated with a Potential Health Hazard

Hazard Severity Categories		
Numerical Designation	Classification	Possible Hazard Outcomes
I	Catastrophic	May cause death or total loss of a bodily system
II	Critical	May cause severe bodily injury, severe occupational illness, or major damage to a bodily system
III	Marginal	May cause minor bodily injury, minor occupational illness, or minor damage to a bodily system
IV	Negligible	Would cause less than minor bodily injury, minor occupational illness, or minor damage to a bodily system

Table 2. Numerical Designations and Descriptions for Hazard Severity Categories

Hazard Probability Categories			
Descriptive Word	Level	Specific Individual Item	Fleet or Inventory
Frequent	A	Likely to occur frequently	Continuously experience
Probable	B	Will occur several times in the life of an item	Will occur frequently
Occasional	C	Likely to occur some time in the life of an item	Will occur several times
Remote	D	Unlikely but possible to occur in the life of an item	Unlikely but can reasonably be expected to occur
Improbable	E	So unlikely, it can be assumed occurrence may not be experienced	Unlikely to occur, but possible

Table 3. Alphabetical Designations and Descriptions for Hazard Probability Categories

*Projects.* The HHA Program primarily provides support to the Army; however, there have been instances where the Marine Corps has asked the HHA Program to provide support to Marine Corps system acquisition managers as well. This section discusses the system background and HHA Program involvement for three developing programs: the STRYKER Family of Vehicles (FOV) (U.S. Army), which has been

selected to be the Interim Armored Vehicle (IAV); the Land Warrior (LW) (U.S. Army); and the Expeditionary Fighting Vehicle (EFV) (U.S. Marines).

**STRYKER FOV.** Former Army Chief of Staff General Eric K. Shinseki and Army Secretary Louis Caldera unveiled the Army Transformation Plan at the Association of the U.S. Army Conference in Oct 99. They spoke of the vision to create a lighter weight force capable of deploying a Brigade Combat Team (BCT) within 96 hours, one Division within 120 hours, and five Divisions within 30 days.

The Transformation Plan includes three phases. The HHA Program has played a key role in supporting all three phases of the Transformation Plan and its significant contributions to each phase are discussed below.

**PHASE I (1999-2001):** The use of lighter weight surrogate vehicles on loan from other governments or systems already in the Army inventory. Surrogate, armored vehicles were provided to the Initial BCT at Fort Lewis, WA. The surrogate vehicles included lighter weight vehicles already in the Army inventory and previously subjected to the HHA process. These initial vehicles will remain in use until replaced by the IAV.

**PHASE II (2001-2008):** The selection, production, and fielding of lighter-weight, commercial off-the-shelf (COTS) IAVs. The HHA Program supported the IAV selection process by providing:

- Inspection of 24 IAV candidates at a Platform Performance Demonstration held at Fort Knox, KY, during Dec 99 and Jan 00.

- Support for the safety release for testing by Army personnel through issuing abbreviated HHARs, based upon lessons-learned from past experience with armored vehicles, and detailed HHARs previously completed on vehicles presented at the Platform Performance Demonstration.

- Attendance at the U.S. Army Tank-automotive and Armaments Command (TACOM) IAV document review meetings involving specifications, test plans, request for proposal, and related program documents.

- An initial HHAR on the IAV as input to the Department of the Army's MANPRINT Assessment for the IAV. The MANPRINT Assessment supported the Army System Acquisition Review Council (ASARC) Milestone I Decision Review in Feb 00.

- Representation on the IAV Source Selection Evaluation

Board (SSEB) held at TACOM and the Bid Sample Team conducting vehicle tests at Aberdeen Test Center (ATC) from Jun to Nov 00.

Companies responding to TACOM's IAV Request for Proposal provided a prototype of their vehicle, the basic IAV or Infantry Carrier Vehicle (ICV), to ATC. Test data collected by the Bid Sample MANPRINT Team was provided to the SSEB MANPRINT Team for inclusion in their evaluation submitted to the Army Acquisition Executive. The Army Acquisition Executive announced his selection and contract award for the IAV on 16 Nov 00. The offer from General Motors/General Dynamics Land Systems (GM/GDLS) was accepted. The GM/GDLS Light Armored Vehicle III will be used as the baseline vehicle for the ICV. During Spring 2002, the IAV was officially named the STRYKER (Figures 4 and 5).



Fig 4. STRYKER ICV.



Fig 5. STRYKER Brigade Combat Team. (SOHAB information provided by John V. Cambre USACHPPM.)

The STRYKER ICV is the basic chassis for seven additional nondevelopmental variants: mortar carrier, reconnaissance, anti-tank guided missile, fires support, engineer support, command and control, and medical evacuation; and two developmental variants: the nuclear, chemical, and biological reconnaissance vehicle and the mobile gun system.

The estimated value of the Army's contract with GM/GDLS approaches \$4 billion for the delivery of 2,131 vehicles by 2008.

Once each variant becomes available for testing at ATC and other locations, HHA test data will be collected to support the completion of HHARs. These assessments will support future ASARC Milestone Decision Reviews.

### Soldier Occupational Hazard Assessment (SOHA)

The USACHPPM Industrial Hygiene Field Services Program has been working with the Army to evaluate Soldier exposure to potential sources of occupational hazards during field training and deployment environments. The USACHPPM is working with various Army Commands, located within CONUS/OCONUS, to access their training and operational world in order to use industrial hygiene sampling and assessment techniques to gather data on Soldier occupational exposures. The methods designed to collect this vital data is called SOHA. The SOHA was developed under the Industrial Hygiene Field Services Program to close the loop on the HHA Program and provide a method to capture, measure, and record potential health hazards and health effects associated with operating newly acquired and existing military equipment with the expressed intent to meet the DOD Force Health Protection policy of documenting occupational exposure of Soldiers over the course of their service. The SOHA supports DOD Force Health Protection policy by providing Soldier exposure assessment information from the use of type-classified equipment over the equipment lifecycle and records this information as part of the Soldiers' medical records. The primary goal of the SOHA is to identify, evaluate, and recommend actions to eliminate or reduce occupational exposures to our Soldiers both in garrison and on the battlefield to as low as reasonably achievable. Recently, the Industrial Hygiene Field Services Program placed new emphasis on this effort by initiating the SOHA for the STRYKER FOV.

*PHASE III (2008 and beyond):* The production and fielding of lighter-weight objective systems, using advanced technologies, currently in the research and development technology base.

The HHA Program will routinely complete HHARs on objective vehicles, destined to replace the STRYKER FOV, as they come out of the research and development technology base and proceed through the Army's MADP.

*Land Warrior.* The LW program provides the first holistic approach to an integrated Soldier system. The LW system includes everything that Soldiers wear or carry in a tactical environment. The LW system is the first generation integrated fighting system for dismounted combat Soldiers, evolving from

the Soldier Integrated Protective Ensemble Advanced Technology Demonstration.

The LW version 1.0 (Figure 6) is an integrated system designed to enhance the lethality, survivability, mobility, command-control-communications, situational awareness, and sustainability of the dismounted infantry Soldier. The current version includes weapons, sensors, laser rangefinder, displays, and integrated load-carrying equipment with ballistic protection, protective clothing, helmet, headset, microphone, computer, navigation, and radios.



Fig 6. Land Warrior system.

The LW system is using an evolutionary acquisition approach, which will develop and field integrated Soldier configurations in a series of three block improvements as technology supporting the program matures:

- The LW – Initial Capability system, which was destined for the 75th Ranger Regiment during fiscal year 2004 (FY04), was deleted as the LW program manager restructured the LW program in Mar 03.
- The LW – STRYKER Interoperability Capability Improvement which will integrate the necessary subsystems for the LW – equipped Soldier to interoperate with some of the STRYKER BCT vehicles in FY05.
- The LW – Advanced Capability which will culminate in the Future Force Warrior Science and Technology investments being made with a projected full rate production to occur in FY10, based on current funding levels.

The HHA Program has been involved with the LW system since its inception in 1994 and has completed nine HHARs on the system and its components. During the HHA process, USACHPPM's Hearing Conservation Program recognized an opportunity with the development of LW version

1.0 to replace a COTS communication headset with an Army-approved communication earplug. The COTS headset provided a communication capability but provided no attenuation of potential noise hazards.

The Product Manager-Soldier Electronics reported that the COTS headset is being replaced with a communication earplug system to provide both hearing protection and communication. This outcome serves as an example of how cooperation among USACHPPM, the item program manager, the MANPRINT community, safety, and a contractor can influence system development to enhance the health and performance of future combat Soldiers.

*Expeditionary Fighting Vehicle.* The latest system being developed by the Marine Corps to enhance their expeditionary warfighting capability is the EFV (Figures 7 and 8). Formerly known as the Advanced Amphibious Assault Vehicle, the EFV is the Marine Corps' number one ground acquisition priority. In the 1980s, the Navy and Marine Corps developed the concept of over-the-horizon expeditionary operations to avoid enemy strengths, exploit enemy weaknesses, and protect Navy ships from increased land-based missile threats and sea-based mine threats. This littoral warfare concept has matured into Operational Maneuver from the Sea, one of the key operational concepts within the Marine Corps' Expeditionary Maneuver Warfare (EMW) capstone concept. The EFV, together with the MV-22 Osprey tilt-rotor aircraft and the Landing Craft Air Cushion, will provide the tactical mobility assets required to spearhead the Operational Maneuver from the Sea concept. Each system is an integrated element that will permit the Navy-Marine Corps team to fully exploit littoral areas as maneuver space. The EFV is critically important to maneuvering a mobile and survivable surface assault force that can quickly secure inland objectives. Fielding the EFV will significantly enhance a currently lacking tactical assault capability, thus enabling the Landing Craft Air Cushion to perform its follow-on assault and logistic functions. In addition to its significantly increased water speed, as compared to the Legacy System, the EFV will provide superior land mobility, increased firepower, and advanced survivability features that compare to the best land-fighting vehicles in the world.

The EFV is an engineering marvel. It measures approximately 30 feet (L) x 12 feet (W) x 10 feet (H). The EFV is operated/maintained by a crew of three Marines and has a troop-carrying capacity of 17 combat-equipped Marines. Key system characteristics include the requirement to travel between 20-25 knots in Sea State 3 and land mobility equivalent to the M1A1 Main Battle Tank. The EFV FOV consists of a personnel variant, EFV(P), and a command variant, EFV(C). The EFV includes a variety of subsystems that allow the vehicle to perform its required operational mission. The major

subsystems are: (1) the hull and frame; (2) suspension and steering system; (3) engine; (4) automotive drive train; (5) marine drive train; (6) auxiliary systems; (7) turret assembly; (8) armament; (9) communications/navigation equipment; (10) fire control system; (11) software; (12) hydrodynamic system; and (13) controls and displays.



Fig 7. U.S. Marine EFV on land.



Fig 8. U.S. Marine EFV at sea.

The existing Assault Amphibian Vehicle (AAV) was originally fielded in 1972, and, although there have been numerous upgrades and overhauls throughout its lifecycle, the AAV will have been in service for 40 years by the time the EFV is fully fielded. In 1988, a series of mission area analyses determined that the AAV was significantly deficient in several important areas, to include water and land speed, firepower, armor protection, and system survivability. Thus, the requirement for a high-water-speed amphibious vehicle.

The EFV's unique capabilities will include: (1) over three times the water speed of the current AAV; (2) the ability to defeat future-threat light armored vehicles; (3) land mobility equal to or greater than the M1A1 tank; (4) significantly enhanced survivability features; (5) effective command and control with subordinate, adjacent, and higher units; and (6) nuclear, biological, and chemical protection for both crew and embarked personnel.

The EFV Program Office is considered a pioneer of Government/Industry teaming because it was one of the first major programs to occupy a shared facility with its prime contractor. The EFV Program was approved to enter the System Demonstration and Development (SDD) phase of the acquisition management lifecycle on 29 Nov 00. The phase contract was awarded on 3 Jul 01 to General Dynamics Land Systems, under their subsidiary General Dynamics Amphibious Systems, Woodbridge, VA. The EFV Program Office and General Dynamics each maintain staff consisting of professionals from the fields of environment, safety, and health, along with other contract and support personnel. The EFV Program is presently assembling nine second-generation EFV prototypes to support SDD testing and one live-fire test vehicle.

The USACHPPM, through the HHA Program, has been providing support to the EFV Program for 4 years, and was involved in the early development and testing of the vehicle. This was a rare opportunity for USACHPPM to actually affect the EFV design and operational characteristics, taking into consideration the health and protection of Marines. The EFV/USACHPPM partnering included assessment from the USACHPPM Hearing Conservation, Industrial Hygiene, Toxicology, Laser/Optical Radiation, Radiofrequency/Ultrasound, Industrial Health Physics, and Ergonomics Programs, as well as assessments from the Walter Reed Army Institute of Research and the U.S. Army Aeromedical Research Laboratory. In addition, other tasks partnered with the EFV Program included the participation of the Air Pollution Source Management, Industrial Hygiene Management, Occupational Medicine, and Surface Water and Wastewater Programs. The HHA Program's present effort is mainly focused on supporting the SDD phase.

The EFV Program has presented some very unique assessment challenges to the various USACHPPM programs involved in the HHA. As with most armor systems, the EFV produces a significant amount of noise. The track, engine, transmission, and water jets are significant sources of steady-state noise, while the 30-millimeter (mm) main gun, 7.62-mm coaxial machine gun, and smoke grenade launchers are all sources of impulse noise. The USACHPPM Hearing Conservation Program has worked closely with the EFV Program to not only assess the noise produced by the EFV, but also to assist in selecting the most appropriate hearing protection. Numerous hearing protectors were evaluated at various speeds and conditions to ensure the EFV would be able to complete its various SDD scenarios without overexposing the vehicle occupants during these trials.

Another hazard typically characteristic of armored systems is the significant amount of heat they generate and retain. The USACHPPM Industrial Hygiene Field Services

Program has collected and assessed data on temperature extremes. Recommendations from that assessed data have resulted in software and operational changes that will reduce the amount of heat within the vehicle while providing vehicle occupants with traditional preventive medicine countermeasures to minimize the potential for heat injury. Another challenge presented to the Industrial Hygiene Field Services Program was the significant amount of weapon combustion products, mainly carbon monoxide (CO), generated by the 30-mm main gun. The SDD prototypes will include design changes and modifications that resulted from weapons firing assessment during the Early Operational Assessment phase. As a result, new weapons firing test data will be collected to determine the efficacy of these design changes. Typically, CO is assessed using the Coburn-Forster-Kane Equation to calculate the amount of carboxyhemoglobin in the blood based on a given CO exposure. An innovative approach by the Industrial Hygiene Field Services Program was to use the Coburn-Forster-Kane Equation as a predictive tool to assist the EFV Program in modifying their firing scenarios to ensure compliance with the military-unique carboxyhemoglobin standard.

These are a few of the examples of the many responsive assessment contributions made by USACHPPM. In addition to providing the EFV Program with an HHAR, the USACHPPM HHA Program participates as a voting member of the EFV Environment, Safety and Health Advisory Board. The Board is directly responsible for managing and tracking EFV hazards. During the previous milestone phase, about 550 potential hazards were identified and tracked. That number has been reduced to slightly over 300 with many of the hazards being effectively controlled, but still actively monitored. Other involvement includes the review of EFV Program documents and test plans. Active participation with the planning and testing communities has maximized the generation of appropriate assessment data without the need for repeating tests.

Early integration of preventive medicine into system acquisition will result in healthier Marines, lower medical costs, and less lost work time along with an increased level of readiness. For the assessment participants, it is perhaps the unique partnering among the USACHPPM programs supporting this effort and the EFV Program and its contractors that has been one of the most rewarding aspects of this endeavor. The ongoing request for USACHPPM support of the Marine Corps' number one ground acquisition priority is another testament to the valuable services provided by USACHPPM and its professionals.

## Future

Rapid advancements in weapon systems technology have resulted in a record number of HHAR requests. In an effort to

manage increased workload and improve services provided to customers in the acquisition community, the HHA Program is currently undergoing a business process reengineering effort. As part of this endeavor, the HHA Program will be streamlining HHAR production to include on-line requests for HHAs, an automated report generation tool, and a significantly improved cost avoidance model. By implementing the proposed improvements, the HHA Program will require less time to provide more meaningful recommendations to combat and materiel developers.

Presently, requests for HHARs are made through hard-copy memorandum. The revised system will allow TRADOC or AMC to access an on-line request form to initiate the process. This step alone will save upwards of 2 weeks in processing time. Once the request is received electronically, HHA project officers and subject matter experts will begin the assessment report production process using a secure automated web-based system. The integrated system will assist the team in identifying potential health hazards, assigning associated risk, and designing recommendations to eliminate or control potential health hazards. In addition, residual risk will be captured and cost avoidance calculated based on the proposed risk reduction. The result will be an automated report production that will provide materiel developers with assessment results in a fraction of the time required using the current hard-copy method.

As part of this larger effort, the HHA Program is revising the algorithms used to calculate cost avoidance. Since 1997, improved Defense Medical Surveillance data has become available as a result of DOD efforts to track exposure and medical outcomes. The HHA Program will use this data to improve the accuracy and precision of its MCAM, thereby providing more accurate and precise cost avoidance figures that have been validated using real-world exposure scenarios. Armed with more accurate and precise cost data, materiel program managers will be able to make better decisions regarding abatement actions and ultimately decide what level of risk (and cost) may be considered acceptable.

## Summary

Since 1981, the Army's HHA Program has provided an invaluable service to combat developers and materiel program managers by providing recommendations designed to eliminate or control health hazards associated with materiel and weapon

systems such as the STRYKER FOV, LW system, and the EFV. The program has consistently strived to improve its services by providing more meaningful assistance to the acquisition community year after year. The HHA Program's MCAM is just one example of the value-added services that the acquisition community has embraced. With the combination of a streamlined report production process and an improved MCAM, the HHA Program will continue to provide its unique services to the DOD acquisition community with greater efficiency, accuracy, and precision.

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# **Dietary Supplement Use in the Military: Do Army Health Care Providers Know Enough?**

MAJ Sonya J.C. Corum, SP, USA†

## **Introduction**

The marketplace is filled with dietary supplements claiming to assist in weight loss or enhance athletic performance. These claims are enticing to Soldiers who are trying to meet or maintain weight standards, improve physical fitness test scores, or be competitive in specialized unit requirements. Many of these products have not been subjected to rigorous scientific examination for the evaluation of safety and efficacy. Regardless of the lack of evidence as to the safety of these types of supplements, Soldiers are using them.

This article provides an overview of the current dietary supplement usage patterns among Soldiers as well as a summary of the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) Dietary Supplements Health Care Provider Survey. It also introduces the current and future components of the Army's dietary supplements consumer awareness/education campaign.

## **Current Situation**

More than half of the U.S. population uses dietary supplements.<sup>1,2</sup> According to the Dietary Supplement Health and Education Act of 1994, dietary supplements include vitamins, minerals, amino acids, enzymes, herbs and other botanicals.<sup>3</sup> The average consumer assumes that dietary supplements are regulated just as any other over-the-counter medication. However, the Dietary Supplement Health and Education Act of 1994 does not require that dietary supplements be proven to be safe and effective before they are marketed. While the use of most dietary supplements is not associated with any serious health effects, certain dietary supplements, especially ones marketed for physical activity, performance enhancement, and weight loss, do pose a potential medical threat. One such product line is the ephedra-containing supplements.

A survey of 2,212 males ranging in age from 18 to 47 years who entered U.S. Army Special Forces and Ranger training schools in 1999 revealed that 64% were using some type of dietary supplement and 35% reported daily use. The most commonly used supplements included multivitamins and minerals, protein powders, and ephedrine products.<sup>4</sup> A similar survey in Aug 02 of 874 enlisted Soldiers assigned throughout

the continental United States revealed that 65% used performance-enhancing supplements while 23% used weight loss products.<sup>5</sup> Ephedrine-containing supplements were among the weight loss products used. Of those enlisted Soldiers reporting dietary supplement consumption, 46% reported experienced palpitations, 30% reported dizziness or confusion, and 25% reported tremors. The Food and Drug Administration (FDA) has received reports from consumers and health care providers of similar adverse events as well as stroke, heart attack, and death related to ephedra and ephedrine alkaloid-containing supplements. As a result, the U.S. Department of Health and Human Services commissioned the RAND study of ephedra to evaluate the safety and efficacy of ephedra and ephedrine for weight loss and athletic performance. The results of the study provide additional evidence that ephedra may be associated with significant health risks.<sup>2</sup> In addition, the RAND study concluded that the use of ephedra-containing dietary supplements is associated with two to three times the risk of nausea, vomiting, heart palpitations, and psychiatric symptoms such as anxiety and change in mood. These negative symptoms are especially evidenced when the supplement is taken with other stimulants such as caffeine.<sup>2</sup>

Due to consumer outcry and litigation, manufacturers are responding to adverse publicity by shifting their ephedra product lines to "ephedra-free" products.<sup>6</sup> However, this shift does not necessarily mean that the ephedra-free products are safer. For example, *citrus aurantium* or bitter orange is an ingredient in many ephedra-free supplements and contains synephrine, which some evidence indicates may cause hypertension or cardiovascular toxicity. Bitter orange may also interfere with the effectiveness of acid-lowering drugs taken for ulcers while increasing the side effects of many other medications like verapamil, lovastatin, and fexofenadine.<sup>7</sup> Another typical ingredient found in ephedra-free supplements is yohimbe. The bark of yohimbe, an evergreen tree, contains a chemical called yohimbine. In typical doses of 15-30 mg per day, yohimbine may cause insomnia, anxiety, hypertension, tachycardia, dizziness, headache, nausea, and vomiting. Larger doses of yohimbine may result in severe hypotension, cardiac failure, and death.<sup>7</sup> Yohimbe is contraindicated if a number of conditions exist, and can increase the side effects of many other medications to include those for diabetes. Like the ephedra-containing products, the ephedra-free products also contain ingredients rich in caffeine such as cola nut, guarana, and mate.

There is some evidence to indicate an increased risk for adverse events when herbs and supplements with stimulant properties are combined.<sup>6,7</sup>

### Dietary Supplements Health Care Provider Survey

There is no question that Soldiers and other beneficiaries are using dietary supplements. As a result, education efforts, like a poster awareness campaign in the Army fitness centers and pharmacies, are being targeted at Soldiers. However, what do health care providers really know about dietary supplements? In Nov 02, the Department of Defense Nutrition Committee in partnership with the USACHPPM provided a web-based survey to U.S. Army Medical Department health care providers to identify possible knowledge gaps. The survey received 406 respondents that included physicians, physician assistants, nurse practitioners, pharmacists, dentists, dietitians, physical therapists, and nurses. These health care providers were asked to rate their knowledge of the following dietary supplements: (1) Bitter Orange; (2) Creatine; (3) Ephedra; (4) Garcinia Cambogia; (5) Ginkgo Biloba; (6) Glucosamine/Chondroitin; (7) Kava Kava; and (8) Yohimbe.

Close to half or more of the health care providers considered themselves experts on ephedra, glucosamin/chondroitin, creatine, and ginkgo biloba. However, they had little or no knowledge of bitter orange, garcinia cambogia, and yohimbe. Table 1 provides the complete results.

Supplement	Little or No Knowledge	Read about the supplement	Studied or Expert
Bitter Orange	84.6%	11.3%	4.1%
Creatine	17.5%	29.2%	53.3%
Ephedra	8.1%	22.2%	69.7%
Garcinia Cambogia	83.6%	9.4%	7.0%
Ginkgo Biloba	14.9%	38.8%	46.3%
Glucosamine/ Chondroitin	12.6%	25.6%	61.8%
Kava Kava	37%	30.3%	32.7%
Yohimbe	35.8%	29.4%	34.9%

Table 1. Knowledge of Dietary Supplement Ratings

The analysis also indicated that pharmacists and dietitians have more knowledge of dietary supplements than the primary health care providers (doctors, physician assistants, and nurse practitioners). Additionally, dietitians ask questions about the patient's use of supplements more often than primary health care providers (Table 2).

Frequency	Primary HCP	Dietitian	Pharmacist
Never or hardly ever	16.3%	2%	31.2%
Sometimes	24%	15.7%	30.3%
Every or almost every patient visit	59.6%	82.4%	38.5%

Table 2. Frequency of Asking Patients About Dietary Supplement Usage

Of those providers who ask about dietary supplement usage, more than 80% ask additional questions regarding the supplements. Dietitians were more likely to refer patients to information about dietary supplements. However, this raises some concern because it is the primary health care providers who have the most patient contact. Available on the USACHPPM Dietary Supplement web page (<http://chppm-www.apgea.army.mil/dhpw/Wellness/dietary.aspx>) are resources to include fact sheets and a brochure for Soldiers entitled *Facts About Dietary Supplements for the Warfighter*.<sup>8</sup> However, the results of the Dietary Supplements Health Care Provider Survey indicate that this simply is not enough to bridge the knowledge gap. The USACHPPM is currently developing materials to arm health care providers with more information about dietary supplements.

The survey asked providers to select the most efficient method whereby they could receive updated dietary supplement information. The top responses included an electronic mail message and one main Internet website. Therefore, USACHPPM is currently developing an electronic newsletter that will be distributed quarterly. Health care providers will have the opportunity to subscribe to the newsletter from the USACHPPM dietary supplement web page. The USACHPPM is streamlining the web page to make it easier for providers and other interested consumers to locate needed information quickly. The USACHPPM is also in the process of developing Technical Guide 296, *A Health Care Provider's Guide to Dietary Supplements*, a pocket reference. In the Health Care Provider Survey, providers also requested professional development regarding dietary supplements. To address this need, a distance learning training course is under development, with a projected completion date of Spring 2004.

### Why Ask About Dietary Supplement Consumption?

Using the Internet is a popular method to obtain dietary supplement information. A search on the Internet will provide over 500,000 site references for dietary supplements related to athletic performance enhancement and weight loss. A review of 338 retail websites found that all made one or more health

claims, and over half omitted the standard federal disclaimer.<sup>9</sup> Thirty-two websites were identified and evaluated for deviance from truth-in-advertising standards. Of the 32 sites analyzed, 41% failed to disclose potential adverse effects or contraindications, and 34% contained incorrect or misleading statements.<sup>10</sup> Soldiers indicate that they use the Internet to obtain dietary supplement information; they also read magazines and talk to their peers.<sup>5</sup> They rarely ask their health care provider for information regarding dietary supplements.<sup>5</sup> A questionnaire provided to 115 pre-surgery patients revealed that a little over half were either taking or had recently taken a supplement. However, 64% of the patients did not inform their doctors about their herbal use, citing that they did not perceive supplements as medication.<sup>11</sup> Dietary supplements often will interact with other supplements, over-the-counter medications as well as prescribed medications. A Soldier presents to the clinic complaining of dizziness and headache. Are these symptoms a result of a medical condition, or are they a result of taking dietary supplements? It is imperative that all health care providers ask patients specific questions about dietary supplement consumption and adhere to the Office of The Surgeon General's Policy on Medical Screening for Dietary Supplement Use regarding documenting the usage in the medication history. A copy of this policy is available on the USACHPPM Dietary Supplement web page.

## Reporting Adverse Events

The FDA has the responsibility of showing that a supplement presents a significant or unreasonable risk of illness or injury under the conditions recommended or suggested in the labeling. One method that the FDA uses to collect evidence is adverse event reporting. It is vital that health care providers report all adverse events or illnesses that they believe to be related to the use of a dietary supplement by calling FDA at 1-800-FDA-1088 or using the website <http://www.fda.gov/medwatch/report/hcp.htm>. As the Army considers future guidance regarding dietary supplements, it is key that not only are adverse events reported to the FDA but that all cases of heat stroke and heat exhaustion include a history of all dietary supplements taken by the patient in the 24 hours prior to the injury. These adverse events must also be reported through the Army Reportable Medical Events System. By reporting adverse events into these systems, health care providers are providing the information necessary to reduce this potential medical threat.

## Summary

The evidence is clear that Soldiers are consuming dietary supplements to include those that may result in an adverse event. The USACHPPM Dietary Supplements Health Care Provider Survey indicates that providers are not asking enough

questions about dietary supplement consumption. It also indicates that health care providers need more knowledge, especially about the newest ingredients in the "ephedra-free" product lines. USACHPPM recognizes this knowledge gap and is currently developing resources to assist health care providers in staying current on dietary supplements.

The dietary supplement industry is a chameleon-like business determined to make a profit; however, health care providers can impact the industry by reporting adverse events.

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# **Protecting Military Forces From Unhealthy Levels of Noise During Deployment**

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## **Introduction**

There is abundant documentation that continuous noise levels in excess of 85 decibels, A-weighted (dBA) pose a health threat in terms of permanent hearing loss. There is not, however, agreement on health threats from lower exposures. Field studies of noise-exposed children show adverse health effects (elevated stress hormones) when 24-hour noise exposures exceed a day-night average sound level (DNL,  $L_{dn}$ ) of 60 dBA.<sup>1</sup> However, adults do not present adverse health effects at a DNL of 60 dBA. Adults function in a world of multiple stressors, so adding noise to the total mix of stressors is usually undetectable in a population of otherwise healthy adults.<sup>2</sup>

During deployment, the total mix of psychological and physiological stressors is amplified, and, for this reason, the Environmental Noise Program at the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) had, historically, assumed that low-level noise exposures less than 85 dBA were not a concern during deployment. In 1996, a trip report received from the Army Research Laboratory's Human Research and Engineering Directorate challenged this assumption. According to French sources, a quarter of French troops deployed to support U.N. operations in Bosnia had worn earplugs to get to sleep.<sup>3</sup> From USACHPPM-Europe came a report that U.S. troops were building sandbag noise barriers around generators to foster sleep. Since the preventive medicine mission includes a responsibility for sleep management, the USACHPPM Environmental Noise Program issued a fact sheet on sleep disturbance from noise.<sup>4,5</sup> In 1999, a request received from Task Force (TF) Hawk, an organization supporting Operation ALLIED FORCE, demonstrated that deployment noise exposures should not be ignored.

In this article, two case studies are employed to show how the adverse health effects associated with noise exposures less than 85 dBA can be mitigated.

### **Case Study No. 1: Rinas Airport**

The TF Hawk deployed to an austere theater through one single aerial port of debarkation, Rinas Airport. This airfield in Tirana, the capital of Albania, also served as the theater staging

base/tactical assembly area. The airfield at Rinas not only had a limited maximum on ground, defined as how many parked aircraft can be worked simultaneously, but also required significant improvements before it was capable of supporting combat operations. In the rush to complete these improvements, noise exposure was ignored.<sup>6</sup> With around 7,000 personnel working at this airfield, it was inevitable that some noise-sensitive activities ended up close to the runways. As a result, personnel complained about the noise, and USACHPPM-Europe conducted a noise monitoring survey. Table 1 shows the results of the survey. The measurements were made using an acoustic measure recommended by the U.S. Environmental Protection Agency, equivalent level (LEQ). The LEQ is the energy average of sound pressure level over a period of time.

Location	LEQ	Sample Time
TF Surgeon's Tent/32d Signal	79.6 dBA	6 hrs 52 min
Flight Operations & Maintenance	83.5 dBA	3 hrs 25 min
1/27th Field Artillery	78.2 dBA	8 hrs 10 min
515th Transportation Company	77.1 dBA	7 hrs 35 min

*Table 1. Equivalent Noise Levels Measured at Rinas Airport in Jun 99*

The primary noise sources were fixed-wing aircraft operating between 0730 and 2000. As would be expected, the highest noise exposure was found at flight operations and maintenance. At the same time, the second highest exposure was found inside the TF Surgeon's tent, an LEQ of 79.6 dBA. Although this exposure did not pose a significant threat in terms of permanent hearing loss, the LEQ was much greater than recommended by Department of Defense (DOD) planners.<sup>7</sup> Table 2 lists those recommendations.

Because the total space was limited by adjacent marshland and the need to maintain an adequate security buffer around the airfield, there was no perfect solution to these excessive exposures. A partial solution was to (1) employ a computer

model to map the quietest locations and (2) relocate the most noise-sensitive activities to the quietest locations.

Activity	All Noise Sources LEQ
Sleeping	45 dBA
Other residential activities (conversation, TV, listening)	50 dBA
Classrooms, libraries, churches, hospitals	50 dBA
Offices-private, conferences	45 dBA
Offices/work spaces, telephone use satisfactory	55 dBA
Work spaces-occasional speech or telephone use	60 dBA
Work spaces-infrequent speech or telephone use	70 dBA

Table 2. Recommended Interior Noise Exposures for DOD Living and Work Areas

The computer model was the U.S. Air Force's NOISEMAP. This model consists of a suite of software components, including a database on all U.S. military aircraft and a set of algorithms to predict the cumulative noise exposures at an airfield from an actual set of daily air operations. Air Force, Navy, and Army planners have used NOISEMAP since the 1970's to advise local civilian governments on areas unsuitable for residential development. NOISEMAP has also

been used for planning on-post military housing, but never before for deployment medical surveillance. NOISEMAP operates on geographical data about the airfield and runways, three-dimensional descriptions of the flight tracks for approach and departure, and the number of each aircraft/operation combination using each flight track during an average day (for example, C-130 at takeoff power). The latter data must be broken down by day (0700 to 2200) and night (2200 to 0700) operations so that a 10-dB penalty can be added to night operations. Because the NOISEMAP database does not contain reference noise data on Soviet and Italian aircraft, the survey officer took sideline noise measurements of U.S. and foreign aircraft, so that the technician at USACHPPM-Main could replace operations by the foreign aircraft with equally noisy U.S. aircraft in the database.\* Figure 1 shows the resulting contours for Rinas Airport. The noise exposure map helps the base commander to relocate noise-sensitive activities; USACHPPM has incorporated the map into its deployment medical surveillance database.

### Case Study No. 2: Bagram Air Base

At Bagram Air Base, Afghanistan, the life support area (LSA) for the TF 44 hospital was located relatively close to flight operations. Recognizing the likelihood that aircraft noise could be a problem, the engineers erected a noise barrier between the runway and the LSA. The barrier was 2.5 meters high and located 150 meters from a flight line. The first row of sleeping quarters was 20 meters from the barrier (170 meters from the flight line). Data taken by the hospital staff

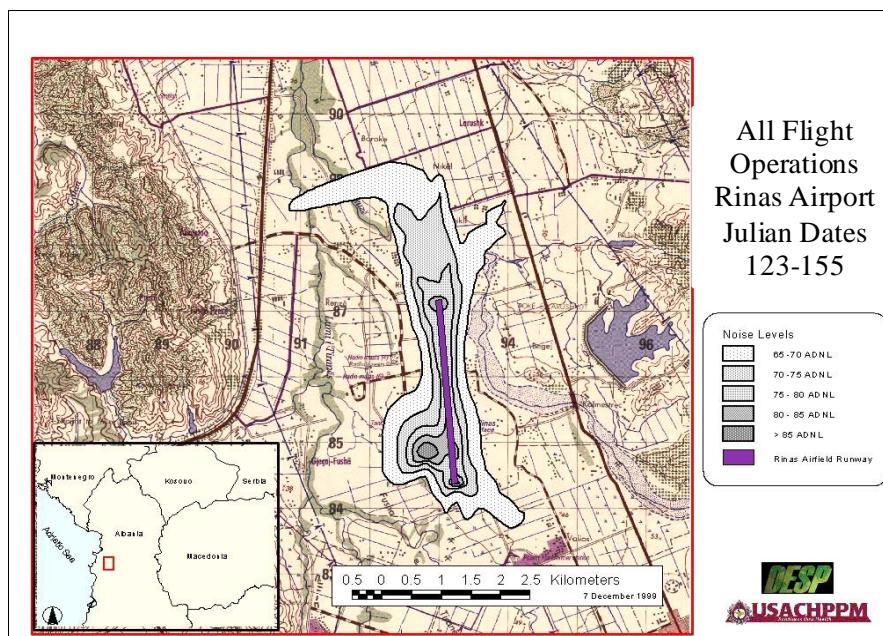
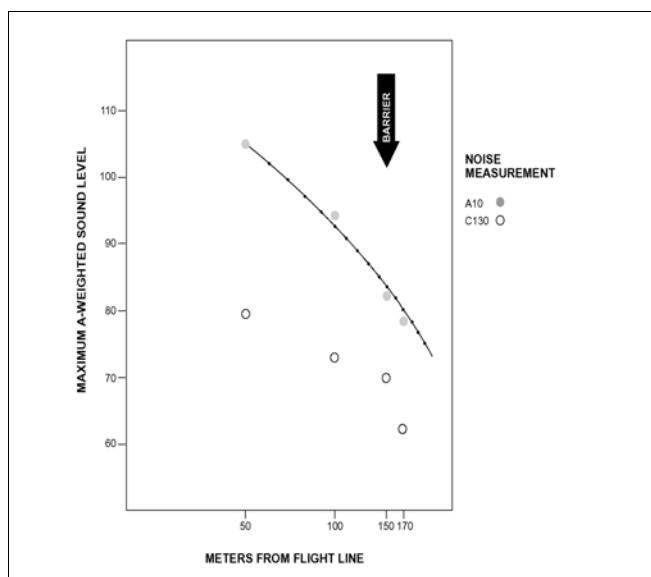


Fig 1. Noise contours over 32 days of flight operations at Rinas Airport.

demonstrated that the barrier had no effect on noise levels (Figure 2). The solid line in Figure 2 shows a best fit for the four measurements of an A-10 at ground idle.

Because the A-10 operations were ground run-ups incident to maintenance, they were conducted during the day. However, some medical personnel work night shifts, and the 45 dBA guidance from Table 1 must apply 24 hours a day. At the 78 dBA level shown in Figure 2, a single second of exposure would raise an 8-hour sleeping LEQ to 52 dBA, and the LEQ would increase by 3 dB for every doubling of seconds of exposure. Ordinarily, ground run-ups should not be a problem because they are not as noisy as takeoffs. However, as can be seen in Figure 2, even a ground run-up is noisy if a tent is located close enough to the aircraft. Not surprisingly, some night shift workers at the TF 44 hospital needed earplugs to sleep.



*Fig 2. Noise levels of A-10 and C-130 operations at the TF 44 hospital area.*

Because there was already a barrier (a HESCO® barrier [HESCO Bastion USA, Hammond, LA]) and that barrier was modular, USACHPPM was asked how high the barrier should be. A standard method for answering that question is to use a mathematical model developed over 30 years ago by a Japanese engineer, Maekawa.<sup>8</sup> When using Maekawa's model, the engineer is concerned with the "path length difference," which is the difference between (1) a straight line drawn from the noise to the receiver and (2) the distance from the noise to the top of the barrier plus from the top of the barrier to the receiver. The greater the "path length difference," the more effective is the barrier. Also, the higher the frequency, the more effective is a particular path length difference.

Spectral analyses provided by the U.S. Air Force indicated that the greatest amount of sound energy from the A-10 is

between 100 to 200 hertz (Hz) (the octave below middle C, 256 Hz, on the piano). Such low frequencies require fairly high barriers. Table 3 lists the attenuations provided by barriers of different heights, as calculated from Maekawa's model. The model predicts that doubling the barrier height by adding a second layer of HESCO units to the existing barrier would still not afford noticeable noise reduction. Some noticeable reduction could be achieved by adding a third layer of HESCO units, but there is some concern about safety. HESCO was originally designed as a soil containment product, not a noise barrier. HESCO evolved into a protective barrier, keeping our troops and assets safe from hostilities. It is a steel-welded mesh, heavily galvanized with a nonwoven polypropylene geotextile insert with infill of sand or soil. The bottom layer is not anchored to a foundation, and a top layer is not anchored to the bottom layer. Thus, a three-layer structure could be unstable. In addition, there can be air gaps between adjacent units, and any holes in a noise barrier degrade performance.

Number of Units (8 ft ea)	Barrier Height	Attenuation	
		100 Hz	200 Hz
8	20 m	19.0 dB	22.0 dB
7	17 m	17.5 dB	20.5 dB
6	15 m	16.0 dB	19.1 dB
5	12.2 m	13.6 dB	16.6 dB
4	10 m	10.8 dB	13.8 dB
3	7.3 m	5.2 dB	8.2 dB
2	4.9 m	none	none

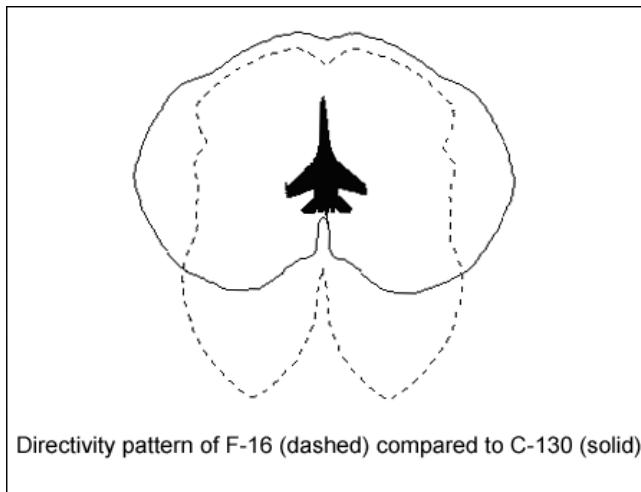
*Table 3. Noise Reduction Achievable at TF 44-LSA with Incremental Increases in Height of HESCO Wall*

## Possible Solutions

The noise field around each military aircraft has a unique directivity. In general, noise is highest to the side of a propeller-driven craft and highest to the rear of a jet aircraft. Figure 3, on the following page, illustrates this principle for the C-130 and the F-16. Ensuring that the engines are pointed away from a hospital is an inexpensive means of noise control.

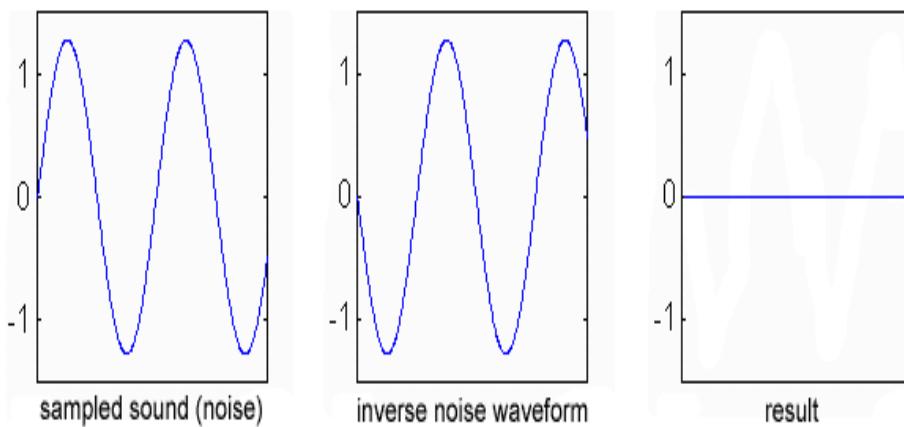
Replacing tents with more permanent structures can also be an effective means of noise control, especially when the noise environment has been quantified with a NOISEMAP analysis to determine how much attenuation should be built into the structure. When using NOISEMAP for communities within the U.S., the Department of the Army categorizes community noise exposures as "compatible," "normally incompatible," and

"incompatible." The determination of whether an existing or proposed building inside a "normally incompatible" zone is "compatible" or "incompatible" depends on the amount of outdoor-to-indoor attenuation. Normal U.S. wood frame construction can be expected to provide a noise level reduction of 20 dBA with the windows closed, and acoustic engineers can advise architects on how to achieve even greater attenuation. Thus, for the LSA at the TF 44 hospital, a combination of more permanent structures and a moderate increase in the height of the existing HESCO barrier (by adding a standard traffic noise barrier available from several U.S. manufacturers) could lead to an acceptable 45 dBA interior noise level.



*Fig 3. Sound levels to the side of a propeller-driven craft and to the rear of a jet aircraft where they are highest. (Source: U.S. AF Research Laboratory, Human Effectiveness Laboratory, Battle space Acoustics Branch, Wright-Patterson AFB.)*

Several companies sell noise-canceling earphones with prices ranging from \$100 to \$300. Many people find these earphones more desirable than earplugs, because (1) earphones are easily removed; (2) noise-canceling earphones attenuate low frequencies far more effectively than speech frequencies, far



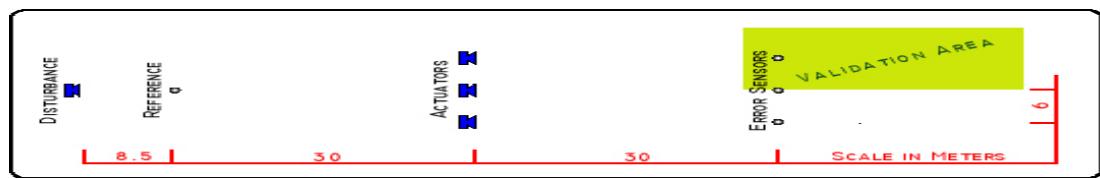
*Fig 4. Schematic explanation of active noise control.*

more effectively than speech frequencies; and (3) some models allow the user to listen to music through the headset. The three graphs in Figure 4 can be used to explain the operation of these devices. The first graph depicts a single "pure tone." The second graph depicts a second pure tone of the same frequency but exactly 180 degrees out of phase with the first. In the noise-canceling earphone, the second tone cancels out the first, and the resulting energy at that particular frequency is 0 (third graph). In the survey of ear protection among French Soldiers in Bosnia, half reported listening to a Walkman® (Sony Electronics, Inc, Park Ridge, NJ) for several hours before going to bed to mask the noise of combat and other activities.<sup>3</sup> Some reported going to sleep with the Walkman on. Acoustically, the noise-canceling earphone can provide far more isolation than a Walkman, but it is much bulkier than a Walkman. Successful sleep with a noise-canceling earphone is probably limited to the small percentage (13%) of the population who sleep on their backs in what the British sleep researcher, Idzikowski, has labeled the "Soldier" and "starfish" positions.<sup>9</sup> Finding the answer is relatively inexpensive. The USACHPPM has provided three pairs of top-of-the-line noise-canceling earphones and a user satisfaction form as part of the support to personnel at the TF 44 hospital.

For the estimated 69% of the population who sleep on their sides, noise cancellation would have to be applied to the sleeping space rather than through earphones. In theory, this application could be achieved through the use of flat panel speakers, and the government of New Zealand has funded research for this option.<sup>10</sup> However, there is no off-the-shelf solution at this time.

Funding from the U.S. Air Force Research Laboratory to an acoustical contractor, Wyle Laboratories, resulted in a demonstration project for active noise control of aircraft runway noise over a larger area. Figure 5, on the following page, shows the dimensions of the demonstration project. According to the authors, reduction of low frequency noise in excess of 10 dB can be achieved over a limited area, such as around a school.<sup>11</sup>

In practice, this technology is probably not suitable for deployment at this time, because (1) the equipment is relatively expensive; (2) loudspeakers cannot be expected to hold up in sandstorms and other harsh weather; (3) the "island of silence" generated within the target area is accompanied by an amplification of sound outside the target area; and (4) there are no acoustical engineers to "tweak" the system. Hopefully, this technology will progress to the point where it is more "user friendly" and adaptable to the rigors of the deployment environment.



wyle laboratories

*Fig 5. Dimensions of a U.S. Air Force-funded demonstration project for active noise control in the vicinity of a runaway (Source: Wyle Laboratories).*

## Conclusion

The collocation of medical facilities with air operations during deployment presents a challenge to the medical staff. On the one hand, the logistics of medical evacuation make it desirable to keep the distance between air evacuation and treatment as short as practical. On the other hand, tents provide virtually no noise attenuation, and established guidelines can easily be exceeded. Fortunately, USACHPPM operates a number of computer models designed to predict noise levels from geographic information systems layers of site plans and operational data on the noise sources. Use of these models should be routinely incorporated into medical operations plans.

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# **Addressing Risk Communication Challenges with the Smallpox Vaccine**

Roxanne D. Smith†

## **Introduction**

In late 2002, the Health Risk Communication Program (HRCP) at the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) began working with the Military Vaccine (MILVAX) Agency to develop a risk communication strategy for effectively implementing the military Smallpox Vaccination Program. The MILVAX Agency was interested in being proactive in its outreach and education on the smallpox vaccine based on lessons learned from the anthrax vaccination effort in 1998 and 1999.

The first step in developing the strategy was to conduct a series of focus groups to gain a better understanding of issues and concerns that might prove to be barriers to the success of the program, and to identify those areas where the MILVAX Agency could further improve communication and education efforts. The focus group tool is typically designed to elicit information in a forum that provides for candid, nonattributable discussion among participants without responding to issues or questions raised. Typically, senior management does not attend, so that responses are more likely to be representative of actual interests and concerns. In order to use this opportunity to practice effective risk communication, the HRCP, along with the Air Force Institute for Operational Health (AFIOH) and the Navy Environmental Health Center (NEHC), agreed to a three-tiered approach:

- The HRCP would conduct a standard focus group session with a facilitator asking a series of questions to encourage discussion among the participants and recording their interests and concerns, but not addressing questions during the focus group session that might come up about the topic; participant responses would be recorded, while participant identities would remain anonymous.
- To ensure that participants received accurate information in response to their questions and to encourage two-way communication, the focus groups would be followed by an open question-and-answer (Q&A) session with a subject matter expert (SME). (In most cases, questions were recorded on flip charts as participants were speaking during the focus group session so the SME could go down the list during the Q&A session.)

- The HRCP would provide risk communication training for those health care providers working with service members receiving the vaccine. (One installation requested the risk communication training.)

The HRCP conducted 14 focus groups from Jan through Mar 03 with 143 service members, their families, and medical staff from all services (Army, Air Force, Navy, Marines). Most participants had not received the smallpox vaccine at the time of the focus groups. The goals of the focus group effort were to learn: (1) how participants felt about the smallpox vaccine; (2) what service members and their families knew about the vaccine; (3) where participants received their information about the vaccine; and (4) what sources of information service members and their families trusted.

## **Focus Groups**

The MILVAX Agency approved the focus group effort in Dec 02. The HRCP began working with other services to arrange the focus groups, specifically with COL Kenneth Cox of AFIOH and CAPT Paul Gillooly of NEHC. These contacts worked with others in their respective services to arrange the focus groups. Table 1, on the following page, summarizes information about the dates, location, and participants in the focus groups.

Due to time and workload constraints, particularly with service members preparing for deployment, some locations did not have full participation. Unfortunately, the services were not able to arrange focus groups with National Guard and Reserve units to hear their perspectives on the Smallpox Vaccination Program.

The questions asked during the focus groups were designed to elicit from the participants their thoughts, opinions, and beliefs about the smallpox vaccine to determine: (1) whether service members were comfortable receiving the vaccine; (2) whether service members had any concerns about the vaccine; (3) what their families thought; and (4) whether health care staff had sufficient information to answer patient concerns.

The MILVAX Agency also wanted to hear: (1) what type of information about the vaccine participants wanted; (2) how

<b>Location and Dates of Focus Group Sessions</b>	<b>Specific Focus Groups</b>	<b>Number of Participants</b>
Wilford Hall Medical Center, Lackland AFB, TX 7 Jan 03	Air Force health care providers	15
Kirk Army Health Clinic, Aberdeen Proving Ground, MD 15 Jan 03	Army health care providers	14
Madigan Army Medical Center, Fort Lewis, WA 11 Feb 03	- Army health care providers - Soldiers - Family members	4 27 3
Naval Amphibious Base Little Creek Virginia Beach, VA 25 Mar 03	Family members and health care providers	13
Naval Medical Center, Portsmouth, VA 26 Mar 03	Immunization clinic staff, other health care providers, and Navy personnel from the Regional Support Group	10
Naval Weapons Station Yorktown, VA 26 Mar 03	Marine Corps Unit	11
Norfolk Naval Base, Norfolk, VA 27 Mar 03	Naval aviators	12
Naval Amphibious Base Little Creek Virginia Beach, VA 27 Mar 03	Navy special operations unit	3
Naval Amphibious Base Little Creek Virginia Beach, VA 27 Mar 03	- Navy shipboard personnel and explosive ordnance disposal divers - Navy shipboard personnel	7 5
Naval Medical Center, Portsmouth, VA 28 Mar 03	Navy and civilian health care providers	13
Naval Medical Center, Portsmouth, VA 28 Mar 03	Navy and civilian health care providers	6

*Table 1. Details on Focus Groups Conducted*

they wanted to receive the information; (3) who they trusted to give them the information; (4) whether participants wanted interactive briefings or written materials such as fact sheets and brochures, or a combination of these methods; (5) where the participants went for information; (6) whether the participants trusted the Department of Defense (DOD) or other Government agencies to give them information about the vaccine; and (7) whether a trifold brochure developed for the Smallpox Vaccination Program met the participants' information needs.

Table 2, on the following page, shows the list of questions that were developed for the focus groups. Not all questions were asked of every focus group.

### **Findings and Observations**

#### *General.*

- Those scheduled to receive the vaccine had significantly more information than those who were not yet scheduled. In some cases, the focus group and the Q&A session

served as a briefing for the service members and their families.

- Many participants were confused about the differences between smallpox disease and the smallpox vaccine. During the Q&A sessions, the SMEs had to repeatedly clarify whether they were speaking about the vaccine and vaccinia, or smallpox disease.

- A number of participants wondered whether there are different strains or mutations of smallpox and if the vaccine still would be protective.

- Participants had concerns about the “old” vaccine versus the “new” vaccine. They wanted to know whether the vaccine used in the 1950s and 1960s was the same as the one being used now. One service member said, “What about the new vaccine that’s about to come out? Why don’t we wait for that one?”

- Participants wanted to know for how long the vaccine is effective. One service member asked whether he had residual immunity from his mother, who received the vaccine 1 year before he was born.

Service Members and Family Questions	Health Care Providers Questions
What have you heard about the smallpox vaccine? What do you know about it?	Do you have concerns about the smallpox vaccine?
How likely do you think you are to be exposed to smallpox if you are deployed? How concerned are you about being exposed to smallpox if deployed?	What kinds of concerns have you heard from patients about the smallpox vaccine?
How likely do you think you are to be exposed to smallpox if you remain in the U.S.? How concerned are you about being exposed to smallpox if in the U.S.?	What do you think are the widely held perceptions that you believe are misconceptions about the smallpox vaccine? What is the basis for each perception? Is there some truth to it? How has the perception, whether valid or not, affected you in your work, or how will it affect your work?
What information sources do you rely on for information about the smallpox vaccination program? Military sources? Civilian sources?	What key information about the smallpox vaccine needs to be communicated to all personnel? To families?
What kinds of concerns do you have about the smallpox vaccine? For yourself? For your family? If you get the vaccine? If you don't get the vaccine? If your family gets the vaccine? If your family doesn't get the vaccine?	From whom would you like to get that information?
Who would you trust for information about the smallpox vaccine (and its impacts)?	What has been done to encourage understanding about the smallpox vaccine? How successful were these efforts? What more could be done?
Where do you go to raise concerns about health issues? Where else? Where do you wish you could go? Where does your family go for information? Where would you like your family to be able to get information?	Do you feel you have the information you need about how the smallpox vaccination program will work and impacts of the vaccine?
What priority has DOD placed on the smallpox vaccination program? On what do you base this assessment?	How prepared are military health care providers to communicate information about the smallpox vaccine and its impacts?
When is the best time to inform service personnel about the need to receive a smallpox vaccine?	Are you comfortable administering the smallpox vaccine?
What key information about the smallpox vaccine needs to be communicated to all personnel? To families?	What opportunities do you have for providing information about the smallpox vaccine to service members?
N/A	What challenges do the Armed Services face in communicating about the smallpox vaccination program? What needs to be improved for communicating information about the program?
N/A	What is the best way to communicate the need for and impacts of the smallpox vaccine to service members? To family members?
N/A	What lessons learned are you aware of from your experience related to vaccination issues/programs? From ongoing studies related to vaccination programs?

*Table 2. Focus Group Questions*

- In nearly every focus group, participants were concerned about whether there were risks to others with whom they may come into contact after being vaccinated: children, spouses, pregnant women, the elderly, other vulnerable individuals, and pets.

- A number of participants were concerned about the deaths of two civilian health care workers with heart disease

who had received the smallpox vaccine.<sup>1</sup> In a focus group that was conducted immediately following the announcement of the deaths, there was lively discussion about the merits of postponing additional vaccinations until more information was available on the possible link to the vaccine.

- Participants had questions about the potential risks of combining laundry and sharing bathroom facilities with those

who had recently been vaccinated. One service member asked, “Should I wash the faucet handle after using it?”

#### *Service Members.*

- Some service members raised concerns about whether smallpox could penetrate protective gear, be spread through the water supply, or be spread by pets.
- Service members wanted to know the ratio of the number of service members who have had adverse effects from the vaccine to the total number who have been vaccinated.
- A number of service members were confused about whether they would be required to lodge away from their families after being vaccinated. They were especially concerned about spending time away from their families immediately before deployment; they suggested vaccinations be given after deployment.
- Service members were concerned about the safety of the vaccine. One service member said, “I had the vaccine when I was young. There wasn’t any hype, it was like a flu shot; my arm swelled. But, I’m worried about long-term effects (of the smallpox vaccine), like (the) anthrax (vaccine).” In several focus groups, service members raised questions about working out while the vaccination was in the process of healing because the local gyms had posted signs saying that those recently vaccinated could not use the gyms until medically cleared.
- Several service members were concerned about whether they could sleep with their spouses after being vaccinated.

#### *Health Care Providers.*

- Health care providers at all levels and in all areas were receiving a significant number of questions about smallpox and the vaccination program. Those who administered the smallpox vaccine were knowledgeable about the vaccine and smallpox disease. In some locations, all providers had been fully briefed and were able to respond to questions from patients. Other providers had limited knowledge of the vaccine and disease; felt ill equipped to answer patients’ questions; and, in some cases, had some of the same misconceptions about the vaccine as their patients.
- Contract health care workers who were being asked to voluntarily take the vaccine to serve as first responders raised the issue of time off from work if they had an adverse reaction to the vaccination. Would the contract employee have to use accrued annual leave and/or sick leave, or would the military pay the contract employee for the time off? Would worker time off cause staffing problems for the hospital?

- Health care providers reported that constant repetition of key information was a crucial part of the pre-vaccination screening process. They provided examples of service members who had heard the briefing, completed the screening questionnaire, spoken with a provider to review the information on the questionnaire, and still revealed for the first time that they had a possible contraindication just as they were about to be vaccinated. In some cases, providers felt that the individual service member might not have wanted to appear “weak,” so did not share relevant information until the last minute.

- One health care provider raised concerns about National Guard and Reserve units. He indicated that active duty service members had time to “warm up” to the idea of the vaccination. However, if the service member was in the Reserves, that individual had little to no mental preparation time.

- At one location, health care providers noted that service members would receive the pre-vaccination briefing and then the providers would informally “quiz” them before administering the vaccine. If the service member was confused or misunderstood key points, then the provider would brief the service member again. At another location, a provider said that there were pictures of smallpox disease posted where the vaccinations were administered. He said no one raised questions about receiving the vaccine after seeing the pictures.

#### *Family Members.*

- Service members do not necessarily share information with family members. One service member said that his family “will look elsewhere (for information) because I won’t tell them exactly what’s going on – I don’t want to scare them.”
- Family members prefer to get information directly and through a variety of sources, and emphasized that more than one method of communication should be used for outreach purposes. Family members suggested receiving information through electronic mail, family resource groups, family service centers, command spouse ombudsmen, installation newsletters, TRICARE publications, newspapers, flyers in high-traffic areas, and health care providers.

- Family members requested that they be included in the pre-vaccination briefing of the service member so that the entire family unit gets the same information at the same time. One spouse summarized this reasoning with: “Not all families communicate well.”

*Perceptions of Threat.* In asking focus group participants whether they felt smallpox was a threat, some health care staff reported that service members did not seem overly concerned

about the threat of exposure to smallpox and, therefore, did not really understand the need for the vaccination. Some service members felt there were greater threats than smallpox. In other cases, health care providers noted that service members asked whether their children and spouses could receive the vaccine.

In general, most focus group participants felt the threat of smallpox was greater outside the continental United States (OCONUS) than in the continental United States (CONUS). However, some service members who were in Special Operations felt the threat of smallpox was greater CONUS than OCONUS because troops would be better equipped during deployment to address the issue. Some participants wondered whether the threat of smallpox was greater than it had been previously because of Operation Enduring Freedom and Operation Iraqi Freedom.

*Information Briefings.* Focus group participants felt it was beneficial to provide information prior to giving vaccinations. They recommended that briefings be held anywhere from a couple of days to 1 month before vaccination. Those that wanted more time between information receipt and vaccination wanted to use the time to conduct independent research on the vaccine.

Based on the focus groups and the Q&A sessions, the HRCP also found that, in general, more mature, experienced officers and senior noncommissioned officers seemed to grasp and understand information about the vaccine and disease more readily than younger, less-experienced service members. As a result, it is important that the information be tailored to the audience, with some service members needing only basic facts and others requiring more detailed information. However, all service members should be given an opportunity to obtain more information on the topic.

Participants identified interactive information exchanges as the most valuable way of getting information to people; written information was inadequate when used alone. People found print and web-based sources of information most useful when coupled with interactive sessions, such as commander's calls or town hall meetings. Health care providers, service members, and family members all advocated use of interactive sessions to establish credibility and address people's concerns.

Feedback on the DOD trifold brochure, *What You Need to Know About Smallpox Vaccine*, was mostly positive, although some health care providers said that its usefulness was limited and it was often thrown away without being read (<http://www.smallpox.army.mil/media/pdf/spTrifold.pdf>).<sup>2</sup> One service member called it "propaganda." Most participants, however, felt it was an important tool to have as a resource to be used in conjunction with a briefing or other interactive exchange or if

someone requested information on smallpox or the vaccine. There was mixed feedback on the pictures: some participants felt the pictures got people's attention; others felt the pictures could unnecessarily alarm people. Some participants noted that the brochure showed a picture of what could happen if service members did not take proper care of the vaccination site but did not show the effects of smallpox disease.

During the later focus groups, other DOD brochures, *Somebody in Your Household Just Got Vaccinated Against Smallpox: What Should You Do?* (<http://www.smallpox.army.mil/media/pdf/Familybrochure.pdf>) and *After You Get the Smallpox Vaccine: Protecting Pets and Other Animals* (<http://www.smallpox.army.mil/media/pdf/petsBrochure.pdf>), were well received.<sup>3,4</sup> Participants felt these brochures addressed some of the most important questions about the vaccine.

*Information Sources.* Service members, their families, and health care providers all considered the Centers for Disease Control and Prevention to be a trusted source of information (<http://www.bt.cdc.gov/agent/smallpox/index.asp>). Providers also mentioned the MILVAX Agency website (<http://smallpox.army.mil>), Johns Hopkins University (<http://www.hopkins-biodefense.org/pages/agents/tocsmallpox.html>), the U.S. Department of Health and Human Services (<http://www.hhs.gov/smallpox/index.html>), and the Maryland Department of Health and Mental Hygiene (<http://www.dhmh.state.md.us/bioterrorism>) as good sources of information. Some health care providers noted the importance of directing people to *legitimate* sources of information to counterbalance the misinformation that is also available. Service members also mentioned WebMD® (WebMD Corporation, Elmwood Park, NJ [<http://www.webmd.comas>]) an alternative source of credible information.

Some participants stated they do not trust the military or the Federal government as a source of information, and gave Gulf War Illnesses and the anthrax vaccine as the reasons. However, most focus group participants expressed trust and confidence in unit medical personnel (physicians and corpsmen/medics assigned directly to units), indicating that the more familiar the source and the more the source shares similar risks (the fact that these medical personnel have been or will also be vaccinated), the more the source can be trusted. Service members and their families said that their personal health care providers are the most commonly used and trusted sources of information about smallpox and other health issues.

Focus group participants also mentioned that the news media is a common source of information. However, a number of participants were concerned that the media tend to sensationalize information about smallpox and needlessly heighten the level of concern.

## **Conclusions**

Based on the findings of the focus groups and the questions/concerns raised during the Q&A sessions, the HRCP found that a proactive information campaign on the smallpox vaccine is necessary and is working. The MILVAX risk communication strategies developed before the start of the DOD Smallpox Vaccination Program were confirmed as sound, and the focus groups provided further opportunity to fine-tune information and communication.

The focus groups reinforced the belief that the target audience for information is broader than just service members. Family members insist upon knowing what their loved ones are facing. All health care providers need to be briefed, whether they administer the vaccine or not, because service members and their families look to them for accurate information. In addition, briefings scheduled in advance of administering the smallpox vaccine allow service members and their families time to understand and discuss the information provided. Service members and their families rely on DOD health care information sources and look to external, civilian sources of information to verify DOD information.

A major benefit of this effort is that it provided rapid feedback to the MILVAX Agency, allowing adjustments and new products to meet the needs identified by service members, their families, and health care providers as the focus groups were conducted. Based on comments from participants in the focus groups, the MILVAX Agency made adjustments to the DOD trifold brochure and produced two additional brochures related to family members and pets.

Another positive benefit resulted from simply asking

service members, their families, and health care providers their opinions. People like to know that what they say matters and has an impact. In the later focus groups, participants heard about how comments and questions from earlier participants were responsible for updates to the trifold brochure and the development of the two new brochures.

The focus group effort demonstrated the need for and value of collaboration and sound risk communication planning. Taking the time and effort to plan and obtain feedback on risk-related issues pays off in the end.

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# **Force Health Protection and Military Drinking Water Supplies**

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## **Introduction**

The U.S. Army engages in operations throughout the world and must capitalize on the latest technology and adopt the most appropriate health criteria to ensure safe drinking water in garrison, during deployments, and during humanitarian operations. The Directorate of Environmental Health Engineering and the Directorate of Health Risk Management of the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) provide technical support on behalf of the Army Surgeon General concerning medical aspects of drinking water issues. The relevance of the USACHPPM programs with respect to all U.S. military operations is demonstrated by the fact that Department of Defense (DOD) Directive 4705.1, which outlines policy, responsibilities, and procedures for management of drinking water supplies during contingency operations, designates the U.S. Army as the DOD Executive Agent for land-based water operations to include: water detection, pumping, purification, storage, distribution, monitoring, and research and development.<sup>1</sup> The Army's responsibility for implementing this Directive is divided among the Corps of Engineers, the Quartermaster Corps, and the Army Medical Department (AMEDD). As a major subordinate command in the AMEDD, the USACHPPM interacts with the Corps of Engineers and the Quartermaster Corps as well as Army Medical Department Center and School's Directorate of Combat and Doctrine Development to effect appropriate changes in field water doctrine.

## **Fixed Facilities**

The U.S. Army bases in the U.S. resemble small civilian cities and towns; to meet the needs of a more sensitive population (infants, the infirm and women of child-bearing age), provision of potable water at these bases must comply with the same regulatory treatment criteria and water quality standards. Several years ago, the Water Supply Management Program (WSMP) of the USACHPPM Directorate of Environmental Health Engineering developed a comprehensive approach, known as the Water System Performance Evaluation (WSPE), to assess Army waterworks and ensure delivery of safe and

palatable drinking water at both domestic and overseas facilities.<sup>2</sup> This approach is incorporated in a protocol that addresses water source, treatment, distribution and storage, water quality monitoring and related activities. For domestic facilities, this comprehensive evaluation is a mechanism for identifying deficiencies and recommending improvements to the water systems to ensure provision of safe, quality drinking water that is safe for consumption by the consumer. The evaluation also assists in ensuring compliance with current and future regulatory criteria. These criteria are defined by the National Primary and Secondary Drinking Water Regulations and related state regulations.<sup>3,4</sup> At fixed facilities outside the U.S., the U.S. Army may purchase water from a host nation supplier and provide any necessary additional treatment, or may operate its own waterworks. Criteria for applicability to these facilities are rooted in the Overseas Environmental Baseline Guidance Document or in host nation requirements, whichever are more stringent.<sup>5</sup> Minimum treatment generally consists of chemical coagulation, sedimentation, filtration, and disinfection for surface water sources and disinfection for groundwater sources and purchased water. The WSPE can be applied to any waterworks throughout the world; the WSMP has performed 140 evaluations at U.S. Army and U.S. Air Force installations worldwide since 1995.

While the WSPE addresses the mission of producing and delivering a dependable and safe supply of water to the customer, the challenges inherent in achieving that mission have expanded subsequent to the horrific events of 11 September 2001(9/11) to include water system security. An intentional contamination or attack to deny or disrupt public water supply could have catastrophic effects on force health. In the Public Health Security and Bioterrorism Preparedness and Response Act of 2002 (Public Law [PL] 107-188), Congress recognizes the need for a more comprehensive view of water safety and security relative to drinking water systems.<sup>6</sup> The PL 107-188 amends the Safe Drinking Water Act and specifies actions that owners/operators of community water systems and the U.S. Environmental Protection Agency (EPA) must take to improve the security of the nation's drinking water infrastructure. Specifically, PL 107-188 states that the owner/operator of a

community water system that serves a population greater than 3,300 people must perform a review of the vulnerability of the system to a terrorist attack or other acts intended to substantially disrupt the ability of the system to provide a safe and reliable supply of drinking water. Such reviews shall include, but need not be limited to: (1) pipes and constructed conveyances; (2) physical barriers; (3) water collection; (4) pretreatment and treatment facilities; (5) storage and distribution facilities; (6) electronic, computer or other automated systems that are used by the public water system (for example, supervisory control and data acquisition [SCADA]); and (7) the use, storage, or handling of various chemicals.

The DOD is currently developing policy and specific procedures for full and timely implementation of the requirements of PL 107-188 at DOD installations and facilities. The Assistant Chief for Staff, Installation Management has issued guidance to Army installations through the Installation Management Agency for compliance with the requirements of PL 107-188.

In response to the events of 9/11, the WSMP developed a Water System Vulnerability Assessment (WSVA) protocol that meets the requirements of PL 107-188 and is based upon the best available information from various Federal agencies and professional associations.<sup>7</sup> The WSVA is designed to provide installation commanders and key staff members with a frank, thorough, and risk-based assessment of the vulnerabilities of their drinking water systems and to recommend countermeasures to lower the risk by reducing the probability and severity of these vulnerabilities. The protocol provides for assessment of virtually any Army water system, regardless of size or complexity, including those systems that purchase water from nearby municipal systems; it addresses water system vulnerabilities that, if successfully exploited, could result in (1) the physical destruction of water system assets; (2) the intentional contamination of raw or treated water supplies; and (3) a cyber-attack that could compromise the water system's ability to produce, store, or distribute treated drinking water.

The ultimate goal of a water system is to safeguard the public health and safety, and to reduce the potential for disruption of a reliable supply of pressurized water. The PL 107-188 also requires that water systems update emergency response plans according to findings of the vulnerability assessment within 6 months of its promulgation; the WSMP developed guidance on drinking water emergency planning in 1998.<sup>8</sup> The EPA has developed a document that provides uniform response, recovery and remediation guidance for water utility actions in response to man-made and/or technological emergencies.<sup>9</sup> This document recognizes five different incident types, but should also serve to guide response, recovery and remediation actions for other threatened or actual intentional

acts that would affect the safety or security of a water system. The five incident types are: (1) Threat of or Actual Intentional Contamination of the Water System; (2) Threat of Contamination at a Major Event; (3) notification from Health Officials of Potential Water Contamination; (4) Intrusion through the SCADA; and (5) Significant Structural Damage Resulting from an Intentional Act.

## **Field Facilities**

Military field operations, which also include sustainment and support operations such as peacekeeping and humanitarian assistance missions, present significant preventive medicine challenges. Because loss of life, health and mission capability from disease and nonbattle injury has historically exceeded that from combat, assuring an adequate supply of safe drinking water in the field has always been a major concern to the Army. The Army, Air Force, Navy, and Marine Corps are all responsible for providing water to their troops. Each Service performs the task and delegates the various responsibilities according to its own needs. For the Army, the Army Engineer units are responsible for source development, which includes well drilling and construction to support tactical water supply points, and construction of fixed and semifixed water treatment and distribution facilities. The Quartermaster Corps is responsible for the actual production and distribution of potable water on the battlefield. The AMEDD is responsible to ensure the potability and palatability of the drinking water.

*Water Quality Doctrine and Standards.* The Army Surgeon General sets health standards and provides doctrine and policy governing potable water quality; the Army, Navy, and Air Force surgeons general have adopted unique Tri-service field potable water standards for use in all DOD land-based deployments outside the U.S. These standards were developed to protect against performance-limiting effects that could compromise operational capability, and to that end the standards address acute rather than chronic health effects. Current water quality Tri-service standards address short- and long-term deployments as well as arid and temperate environments. The U.S. Forces must also meet multinational standards when in combined operations with other countries. It must be recognized, however, that perceived threats to water quality are not constant over time or region; because U.S. Armed Forces are increasingly involved in prolonged overseas military operations other than war, studies in progress at USACHPPM expand the Tri-service standards to include more toxic industrial chemicals and to address lifetime health concerns incidental to water contamination.<sup>10</sup> The Tri-service surgeons general have also promulgated standards for individual nerve agents, to be applied when field analytical/capability becomes available. In addition, goals have been established for individual nerve agents, corresponding to red blood cell cholinesterase

depression of no more than 25%, in response to recommendations of the National Research Council Committee on Toxicology.<sup>11</sup>

Irrespective of the short- and long-term standards, the decision to accept a water source for potable use lies with the field commander. His decision will be based on the concept and principles of Operational Risk Management (consideration for the health of his troops while considering the overall risk associated with the exigencies of the mission). The command surgeon on the battlefield is responsible for protecting the health of the Soldier; in this role, he is the approving authority for water sources and water treatment methods and alternative measures to maintain the potability of water. Preventive medicine personnel function similarly to local public health departments to perform periodic inspections of water sources, test finished water quality, and inspect water treatment and storage equipment. The unit field sanitation team in each Army company-sized unit is the key link for water quality at the unit level.

*Water Treatment Equipment.* The earliest military field water treatment system was the mobile water purification unit, which used sand filtration and chlorination and was employed by the American Expeditionary Force in World War I. Subsequently, the ERDLator (named after the Engineering, Research and Development Laboratory at Fort Belvoir, VA), a mobile water treatment unit that combined coagulation, flocculation, sedimentation, diatomaceous earth filtration, and hypochlorite disinfection, became the principal water treatment unit employed by the Army in World War II, the Korean War, and the Vietnam War. It reliably produced safe, pathogen-free drinking water. As the nature of Army operations evolved, the need arose for equipment capable of processing different types of raw water, and in 1979 the ERDLator was replaced by the reverse osmosis water purification unit, or ROWPU, which for the first time, made it practical to purify seawater on a large scale. Reverse osmosis (RO) is the foundation of land-based water production for U.S. Armed Forces in deployments. The 600-gallons-per-hour (gal/hr) ROWPU is trailer-mounted or skid-mounted, air-droppable, and requires a dedicated 5-ton prime mover. It is designed to produce 600 gal/hr (2271 liters per hour [L/hr]) from freshwater sources (1,500 milligrams per liter [mg/L] total dissolved solids [TDS] or less) or 400 gal/hr (1514 L/hr) from saline water sources (35,000 mg/L TDS or more) at a temperature of 25°C. The 3,000-gal/hr ROWPU can be shipped aboard U.S. Air Force aircraft in an 8x8x20-foot (2.4x2.4x6.1-meter [m]) International Standardization Organization (ISO) container with supplies and ancillary equipment. It can be mounted on a standard 30-foot (9.1-m) military trailer, requires a 60-kilowatt (kw) utility diesel generator, and is designed to purify 3,000 gal/hr (11,355 L/hr) from freshwater sources and 2000 gal/hr (7570 L/hr) from

saline sources. All ROWPU models incorporate multimedia and cartridge filters ahead of thin film composite RO membranes and are equipped with granular-activated carbon units for treatment of nuclear, biological, and chemical (NBC)-contaminated water. The ROWPU provides a military capability to produce potable water from a raw water source of virtually any quality in a wide range of geographical areas around the world.

Evolving requirements have led to the development of the 1500-gal/hr tactical water purification system (TWPS), as well as the 125 gal/hr lightweight water purifier (LWP), by the U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC). The TWPS, designed to purify 1500 gal/hr (5678 L/hr) from freshwater sources and 1200 gal/hr (4542 L/hr) from seawater, differs superficially from the 600-gal/hr ROWPU (which it will replace on a one-for-two basis) in that a membrane microfilter replaces the multimedia and cartridge filters of the ROWPU. However, the TWPS (as well as the LWP) incorporates significant technological upgrades in other major components, such as controls, pumps, and membranes. The TWPS is trailer-mounted or skid-mounted, air transportable with accessories in an ISO container, and is deployed with activated carbon and ion exchange resin over packs for additional treatment of water in an NBC environment. According to the Operational Requirements Document, “the TWPS will support combat, combat support and combat service support missions at all echelons.”<sup>12</sup> The LWP, designed to purify 125 gal/hr (473 L/hr) from freshwater sources and 75 gal/hr (284 L/hr) from seawater, can be conceptually envisioned as a scaled-down TWPS. It can be disassembled into modules transportable by four-person teams. According to the purchase description, “the LWP System is intended to improve the responsiveness of water support to early entry, highly mobile forces throughout the spectrum of conflict in peace and war, and will provide quality water support to small units and detachments where distribution of bulk water is not feasible or practical.”<sup>13</sup>

The USACHPPM has studied the ability of the TWPS and LWP to reduce hypothetical maximum challenge levels of NBC agents to the Tri-service standards.<sup>14,15</sup> Except in a few cases where data are insufficient, USACHPPM is confident that the TWPS and LWP, when equipped with activated carbon and ion exchange over packs, will meet these requirements and will provide safe, palatable water to military personnel and others in the field. The TARDEC is currently carrying out studies of rejection of lewisite, hydrogen cyanide and radioiodine by the TWPS and LWP to resolve remaining uncertainties. However, the question of treatment for removal of many toxic industrial chemicals, volatile organic compounds in particular, has yet to be adequately addressed. There are virtually no standards for biological agents in water, nor in most cases are there data

available to develop such standards, notwithstanding which, USACHPPM believes that contamination of RO product water by either replicating (live) agents or biotoxins could only occur post-treatment.<sup>16</sup>

The most common means of water supply to the individual Soldier is bottled water, which may be shipped from the U.S., purchased locally, or field packaged in 1-L and larger plastic containers using Quartermaster assets.<sup>17</sup> Because field-packaged water need meet only Tri-service standards, while water shipped from the U.S. should meet the U.S. Food and Drug Administration bottled water standards, there can be significant variation in the quality of bottled water provided to the individual Soldier. The single warfighter or small units may also be supplied any of several commercially available individual water purifiers, noting, however, that none of these devices has been subjected to adequate efficacy testing, nor indeed is there yet a suitable health-based protocol for such testing.<sup>18</sup> The TARDEC is presently investigating the practicality of condensing and purifying water from vehicle exhaust, and other studies involve condensing water from the atmosphere.

To relieve the demand for potable water and to reduce wastewater discharges, it is projected that recycle/reuse of shower and laundry wastewater will be practiced at Force Provider facilities, which are mobile tent cities that provide billeting, mess, exercise, and recreational services to Soldiers temporarily relieved from combat and other duty stations. With this effort has come the need to generate human health criteria for the recycled water. These USACHPPM-developed criteria, now undergoing review by the Army Surgeon General, are based on the short-term Tri-service drinking water standards and the EPA Guidelines for Water Reuse, but also include treatment requirements.<sup>19,20</sup> Development of a wastewater treatment scheme capable of meeting these criteria is in progress at the TARDEC.

*Storage and Distribution Equipment.* The potable water storage and distribution system (PWS/DS) is the primary means for the receipt and storage of bulk water and for its issue to deployed forces. Each PWS/DS can receive and distribute water to and from both hose line and tank truck. The system capacity is dependent on the number and size of fabric tanks used. The PWS/DS can issue water to tank trucks, water trailers, the forward area water point supply system (FAWPSS), or small unit containers. The FAWPSS is a helicopter-transportable, self-contained, gas- or diesel-operated unit that dispenses potable drinking water to troop units from 500-gallon (1892 L) collapsible water storage and dispensing drums. These drums provide water to a 125-gallons-per-minute (gpm) (473 L/min) centrifugal pump that discharges water to four distribution nozzles. Potable water is transported in 3,000- and

5,000-gallon (11-m<sup>3</sup> and 19-m<sup>3</sup>) semitrailer-mounted fabric tanks, in 400-gallon (1514-L) water trailers or by means of a collapsible, self-supporting fabric pipeline, known as the tactical water distribution system or TWDS, as much as 10 miles (16 km) in length. Storage equipment includes a variety of containers ranging in size from 5-gallon (19-L) water cans to 50,000-gallon (190-m<sup>3</sup>) collapsible tanks.

*Water Quality Monitoring.* A number of different organizations monitor the quality of drinking water supplied to U.S. personnel and others in the field. Water purification teams are responsible for operational monitoring to ensure the efficacy of water purification equipment and the treatment process. Health monitoring of drinking water supplies in the field is the responsibility of several organizations, including the preventive medicine detachments. Preventive medicine personnel, in addition to approving the raw water source, certify that product water is in compliance with the required field water standards at the point of production, ensure maintenance of the recommended chlorine residual at the unit level, and perform periodic sanitary inspections of the water system(s). The field medical units use the Water Quality Analysis Set - Preventive Medicine (WQAS-PM) or commercial, off-the-shelf replacements and the Water Quality Test Kit, Chemical Agent (M272 Kit) to perform health monitoring. The M272 Kit is not able to monitor the chemical agents to the current Tri-service standards; research is in progress by the U.S. Army Soldier and Biological Chemical Command to field a replacement kit to monitor for biological and chemical agents to required levels of concentration. Also under development, by the U.S. Army Medical Research and Materiel Command, is a rapid bacteriological test kit capable of detecting coliform bacteria at the level of one organism per 100 milliliter (mL) in 4 hours or less. Concerns for possible adverse lifetime health effects from consumption of field potable water have mandated selective sampling and analysis beyond the requirements of the Tri-service standards, and for this purpose the 520th Theater Army Medical Laboratory has more sophisticated analytical capability, such as gas chromatography/mass spectrometry, to perform a much wider variety of chemical analyses. Samples are also collected for complete water analysis at USACHPPM laboratories or other approved domestic or overseas facilities.

## Summary and Conclusions

Potable, palatable drinking water is critically vital to our health and well-being, in garrison as well as in the field environment. In garrison, the installation commanders are responsible for providing safe and palatable drinking water to the Army communities. In austere field environments and during military operations, the quality of drinking water becomes even more important in order to minimize disease and

nonbattle injuries. The Army Corps of Engineers is responsible for source development, the Quartermaster Corps has the responsibility for water production and distribution on the battlefield, and the medical community is responsible for ensuring that the water is of the highest quality possible. Field water purification is enabled by means of various reverse osmosis units that can produce potable water from a source of virtually any quality, including seawater. At the level of the individual warfighter, bottled water is available, as well as various individual water purification devices, most of which lack adequate and appropriate medical evaluation. The Army has conducted a number of challenge studies on its reverse osmosis membranes; however, additional studies are still needed to verify that certain toxic industrial chemicals and NBC agents can be effectively removed. Nevertheless, USACHPPM remains confident that the currently fielded reverse osmosis systems with activated carbon and ion exchange over packs, as well as those under development, will produce potable water from virtually any water source.

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# **Deployment Exposure Assessment and the Role of Biomonitoring**

Coleen Baird Weese, MD†

## **Introduction**

When a patient presents to a health care provider in the post-deployment setting, symptoms that cannot easily be categorized as to etiology are a concern both to the provider and the patient. Post-deployment encounters have been influenced by the reports of unexplained illness following the first Gulf War. While the disease and nonbattle injury rates for the first Gulf War were very low in comparison with other conflicts, the full public health toll was not appreciated for many years. Over 60,000 individuals eventually sought evaluation as part of the registry programs open to Persian Gulf veterans and their families.<sup>1</sup> While it is certainly reasonable to consider potential exposures that occurred during the deployment in relation to presenting symptoms, historically, the lack of exposure data has limited the ability of a provider to assess this potential relationship. The exposures of interest to both providers and researchers included infectious diseases, pyridostigmine bromide, immunizations, pesticides, chemical agent resistant coating paint, depleted uranium, petroleum products, oil well fires, biological warfare agents, and chemical warfare agents. The Institute of Medicine (IOM) evaluated the availability of exposure data after the first Gulf War and concluded, "Although a wide range of possible exposures might be associated with adverse health outcomes in Persian Gulf War veterans, data on these exposures are often not available; when they are available, they are poorly documented. This lack of exposure information is at the core of frustration in obtaining answers from epidemiological studies. Self-reports of exposure and estimates of individual exposure from unit level measurements will be subject to so much error that they are likely to yield inconclusive results and additional questions."<sup>2</sup>

## **Exposure Reporting**

Self-report of exposure is not uncommon. Of the 18,075 Comprehensive Clinical Examination Program (CCEP) participants, over 90% reported exposure to diesel and other fuels, over 80% to oil fire smoke, and 75% to solvents. The CCEP provided evaluation for all Persian Gulf War veterans seeking evaluation and created a registry of their history and health status. Participants were self-referred, which could mean that those who participated were more concerned with their health than other veterans. However, it may be reasonable to assume that this self-report is accurate, since service members may consider being near a vehicle while it is fueled as a fuel

exposure, and solvent use may occur during weapons cleaning, both common occurrences in a deployed setting. Self-report of exposure does not necessarily equate to harmful exposure. However, self-report of exposure to nerve agent was at about 20% and 5% for mustard or blister agent.<sup>3</sup> While there was a known problem with false alarms on chemical agent detectors, there is no evidence to support that exposure occurred with this frequency during the conflict. Yet, approximately 4,000 service members reported an exposure to nerve agent during an evaluation with a provider.

Since 1999, the Army Medical Surveillance Activity (AMSA), part of the United States Army Center for Health Promotion and Preventive Medicine (USACHPPM), has received, tabulated, and archived all completed pre- and post-deployment survey forms (DD Forms 2795 and 2796). Until recently, these forms asked, "Do you have concerns about possible exposures or events during this deployment that you feel may affect your health?" The form contained an area for individuals to write in free-text concerns. In 2002, there was an analysis of 104,996 completed forms that were archived at AMSA. These forms covered major deployments during the period from 1 Oct 99 to 30 Sep 01 and thus did not include forms related to the current Operation Iraqi Freedom. The forms were analyzed to assess a baseline of the types of post-deployment exposure concerns. This information is useful to identify potential exposures requiring evaluation and to promote better risk communication to Soldiers regarding potential exposures not considered to be harmful. In this analysis, 4.3% of Soldiers noted a concern regarding exposures that they thought might affect their health. The highest numbers of exposure concerns were in the general category (22% of the total), the chemical category (21%), and the nonenvironmental medical category (for example, rash and respiratory complaints) (19%). Within these categories, air pollution, dust and tuberculosis were specifically cited.<sup>4</sup> Although the percentage of Soldiers reporting concern regarding an exposure was much lower than that noted in the CCEP registry, it would be difficult for a provider to discuss these concerns with a patient in the absence of objective exposure information. In the same analysis, post-deployment forms available from troops located in Uzbekistan demonstrated that 48% of those completing forms noted an environmental concern. Another analysis of a cohort of Soldiers prior to, during, and on return from a recent deployment to Bosnia noted that up to a third stated that they were exposed to a variety of contaminants, to include chemical

agents.<sup>5</sup> No objective evidence confirms these exposures; indeed, air monitoring at the location would suggest that no exposures of concern occurred.

The post-deployment health assessment form (DD Form 2796) has recently been expanded to four pages. This expanded questionnaire includes 14 potential exposures, ranging from depleted uranium to solvents, paints, and a variety of fuels and smokes which may be hazardous; to N-diethyl-meta-toluamide or DEET and permethrin-treated uniforms, which are not considered hazardous if used correctly. Soldiers are asked to check if they were exposed sometimes, often, or not at all. This form will likely generate a demand for objective exposure information to aid in the interpretation of concerns.

### **Improving Exposure Assessment**

In 2000, the IOM published a report assessing the progress of the Department of Defense (DOD) in implementing recommendations for improving medical surveillance made by the IOM and several other committees and boards.<sup>6</sup> The report recommended that DOD use a systematic process to prospectively evaluate non-battle-related risk associated with activities and settings of deployments. This recommendation included the collection and management of environmental data and personnel location, biological samples, and activity data to facilitate analysis of deployment exposures and to support clinical care and public health activities. Progress in this area includes: (1) intelligence-based evaluations of locations and histories of the locations; (2) assessments of the occupational and environmental health (OEH) threats in a location; and (3) sampling of air, water, and soil as indicated to assess the health threat. The USACHPPM Deployment Environmental Surveillance Program assists in the evaluations where needed, generates reports including recommendations and countermeasures, and archives the results. Many OEH assessments have occurred and continue to occur. Currently, large base camps in deployed settings are evaluated for potential risks while the sites are under consideration for selection. Intelligence on past activities in the area, current industry and potential emissions, stored chemicals, etc., are considered, as well as whether the site could have been previously used as a staging area by other countries and subjected to spills or discarded hazardous waste. Troop locations can be selected based with regard to proximity and plume direction from industrial facilities. Once a site is marked for use, general evaluations for OEH threats may be followed by more detailed sampling of air, water, and soil as circumstances suggest and resources allow. Reports of the health assessments are written and archived. At the time of the assessments, if health risks are identified, appropriate countermeasures are recommended, such as cordoning off an area of contaminated soil or covering or removing it. The USACHPPM Technical Guide 230,

*Chemical Exposure Guidelines for Deployed Military Personnel*, provides concentrations of chemicals (in air, water, and soil) representing high, medium and low risk for short- and longer-term exposure.<sup>7</sup> This document is currently under review by the Committee on Toxicology of the National Academy of Sciences.

The most exhaustive sampling and analysis for environmental exposures will still have some shortcomings. A 2001 Government Accounting Office report noted that the DOD faced a formidable challenge "because of the uncertainties about what conditions may exist in a deployed setting, such as potential military conflicts, environmental hazards, and frequent troop movements."<sup>8</sup> Sampling provides a rough assessment of the general health risk associated with a measured amount of contaminant at a given point in time. Circumstances of exposure and individual locations change, as does weather and the level of activity, adding to uncertainty in the assessment of individual risk. Sampling cannot be conducted at all locations at all times, and troops may move through areas for which no sampling data is available. The identification of a chemical contaminant in air, water, or soil, however, does not result in a direct prediction of risk to the human or biological receptor. Sampling for chemical residues in various media is clearly useful in the assessment of risk, but knowledge of the frequency, duration, and extent of exposure is needed. Exposure of humans by contact to contaminated environmental media is defined as an external dose, whereas internalization of the contaminated media, via inhalation, ingestion, or dermal absorption, results in an internal dose. The amount of this internal dose necessary to elicit a response or health effect is referred to as the biologically effective dose and is typically the information needed to more accurately assess individual risk.

### **Biomonitoring**

The measurement of internal dose of an environmental chemical is known as biomonitoring. Human biomarkers serve as indicators of actual or potential events in biologic systems or specimen. There are three types of biomarkers: biomarkers of exposure, biomarkers of effect, and biomarkers of susceptibility. Biomarkers of chemical exposure are measured as the unchanged, parent chemical substance, its metabolite, or a product of its interaction with a target within the body. An ideal biomarker of chemical exposure is one with the ability to detect and measure the parent substance, or a substance-specific metabolite, in an easily accessed tissue, fluid, gas, or excretion product at a sub-toxic concentration. Biomarkers of effect are defined as any measurable biochemical, functional, or structural change that is associated with exposure and interaction to an agent. In some instances, these effects do not represent injury, impairment of health, or disease. Biomarkers of effect are

frequently not specific to a given exposure or a specific agent. A relationship between exposure (acute, subacute, or chronic) and the biomarker of effect must be established in order to determine causality. Biomarkers of susceptibility are indicators of an individual's ability to respond to a specific exposure. This type of biomarker usually represents inherent or acquired limitations of the individual, but its presence can also indicate a beneficial condition or response. The lack of an enzyme, such as glucose-6-phosphate dehydrogenase (G6PD), or the presence/absence of a gene or genes (sickle cell trait or disease), is currently used by the Armed Services as markers of susceptibility.

**Biomarkers.** Biomarkers of exposure have received increased interest due to the current focus on deployment exposures. Presidential Review Directive 5, *A National Obligation: Planning for Health Preparedness for and Readjustment of the Military, Veterans, and Their Families after Future Deployments*, specifically recommends expanded research in human biological monitoring to increase the number of chemicals that can be assessed and improve the analysis time and data interpretation.<sup>9</sup> The IOM 1999 report titled, *Strategies to Protect the Health of Deployed U.S. Forces Task 4: Medical Surveillance, Record Keeping, and Risk Reduction* requires the use and testing of exposure biomarkers for DOD force health protection.<sup>6</sup> These recommendations have also surfaced in DOD Directive 6490.2, *Joint Medical Surveillance*, and DOD Instruction 6490.3, *Implementation and Application of Joint Medical Surveillance for Deployments*.<sup>10,11</sup> Specific instructions identifying the circumstances that require biomonitoring are not provided. In the past year, a policy to provide instruction in the use of biomonitoring for exposures to depleted uranium, nerve agent and lead was drafted, with a depleted uranium policy released to address the recent conflict in Iraq. Exposure to depleted uranium was noted by up to a third of CCEP participants during the first Gulf War.<sup>3</sup> As assessments of exposures through external sampling increases, questions arise frequently as to the need for biomonitoring, and is often viewed as a critical piece of information for use in the post-deployment setting to evaluate exposure concerns.

Currently, internal dose is becoming measurable at the part-per-trillion (ppt) levels in tissue, serum, urine, or other biological samples. This level is well below the internal dose that has traditionally been measured in occupational settings to evaluate exposures at typical or permissible workplace levels. Ideally, a biomarker should be measurable at a level below which there are no significant or permanent untoward effects, but should have some prognostic information or reference standard available for use in interpretation. In order for a biomarker of exposure or effect to be a valuable tool in medical surveillance, the dose-response relationship between exposure and effect must be established. The method for detecting and

measuring the biomarker must be sufficiently sensitive and specific. The measured biomarker may not be specific to exposure to one specific agent, or exposure to only one source of the agent, complicating interpretation. The period of time in which the parent or initial agent, or its directly related metabolite or effect, can be detected in the body determines when specimens for these indicators must be obtained; a biomarker with a short half-life may be eliminated before realization that an exposure occurred. This makes the use of biomonitoring in the post-deployment setting rarely indicated. One exception is the use of biomonitoring of urine for depleted uranium for which toxicokinetic information allows collection and interpretation in the post-deployment setting where indicated.

**The Risks.** There are risks associated with the use of biomarkers. While the physical risks of biomarkers are small and readily manageable, most service members will assume that the process of biomonitoring was initiated related to a substantial exposure, even if they are asymptomatic. Therefore, biomonitoring for strategic purposes (to document the absence of significant exposure) or potential retrospective epidemiological purposes must be accompanied by clear information communicated with this in mind. This is essential to prevent unnecessarily heightening the service member's fear of his operational environment. The collection of a biomarker will not definitively exclude the possibility that exposure occurred. This may be due to metabolism/excretion prior to sample collection, detection limits for the test, etc. While most toxicants can be detected in the body in the range where they cause acute effects, threshold levels for chronic effects in the body are essentially unknown. Therefore, the test may not serve as a good argument that sufficient exposure has not occurred, even if the toxicant is measured at what would be considered "low level." Finally, a one-time sample rarely gives useful information about cumulative exposures or peak exposure, nor can it be readily used to extrapolate to chronic exposure.

The potential for false positive results presents the risk of unnecessarily affecting the conduct of the operation or raising service member and family health concerns. Once these concerns are raised, especially for a high-concern hazard such as depleted uranium or chemical warfare agents, it is difficult to undo the harm even after the sample is confirmed as a false positive. The use of biomarkers with ambiguous or undetermined interpretations, or unknown or unestablished normal levels presents a significant risk because of our inability to explain the health impact of the results to the service member, the service member's family, the U.S. Congress, or the media. This is particularly true of biomarkers of exposure to toxicants with a short half-life, high variability in the population, poor correlation to health effects, or with little prognostic information. While there are some referent values in the ppt ranges available for the general population (not occupationally exposed) in the

Second National Report on Human Exposure to Environmental Chemicals, this report does not provide any information regarding the interpretation of these levels for health effect or prognostic purposes.<sup>12</sup> The report does, however, serve as a comparison point for levels of chemicals in blood attributable solely to environmental exposure without a known dominant source.

*When is Biomonitoring Indicated?* Ideally, the use of biomonitoring should be guided by decision criteria that consider overall risk and benefit. The decision to conduct biomonitoring should be based on a credible threat and a validated tool. Biomarkers of exposure may be used when warranted by the threat, required by current OEH standards of practice, or required to confirm exposures when other means are not available. Strategically, biomarkers may also be used to archive exposure levels for future epidemiological use when concerns regarding toxicants with delayed health effects are credible, or if the toxicant is operationally sensitive (for example, chemical warfare agent, depleted uranium). This should be balanced by consideration as to whether or not the biomarker can adequately confirm or exclude the exposure given the interval between exposure and sample collection. Biomarkers should be used in these situations only when the test is reproducible, validated, and quantitatively relatable to the relevant range of exposures. They should also be feasible with minimal risk in a deployed setting. These tests should also have minimal analytical error and biological variability. Particularly with respect to documenting a single level of exposure to a hazard with delayed health effects, a full program of risk communication and education must accompany testing and there must be a pre-positioned plan for interpreting and communicating the results and their significance. These criteria for decision-making are discussed in detail below, and listed in Tables 1 and 2 on the following pages.

Exposures of concern may range from a chemical agent release, uncontrolled emissions from operational industry in the area of troops, or a spill discovered due to symptoms in a group of Soldiers working nearby. In situations where external monitors can verify that significant exposures are not occurring, biomonitoring may be unnecessary. In situations where external measurement is not possible, or exposures can occur through multiple routes of exposure, measurement of internal dose may be more important. A credible exposure that cannot be documented by external monitors is a sufficient justification to consider the use of biomonitoring.

Consideration must be given to the availability of health risk/exposure data from other sources such as external and ambient monitoring. Biomonitoring is not without risk and should not be used when an easier and less invasive monitor would provide the same information. Value added must be

seriously considered. Standards for many hazards in air, water, or soil have been established by the Federal Government, the DOD, the Department of the Army and consensus organizations. Monitoring results can be compared to the relevant standard, in the relevant media (air, water, or soil) with consideration to the current exposure scenario and whether it differs from the intended exposure scenario of the standard. Many short-term exposure limits protect from acute effects, but do not definitively address delayed effects. Long-term exposure standards, where they exist, may have been created for the general population, or may include safety factors that may or may not be necessary for deployed forces. Measurement of an external exposure that exceeds a relevant standard is a sufficient justification to consider the use of biomonitoring.

The use of some biomarkers is well-defined by current occupational health practices and requirements. Conditions under which bioassays for radiological materials (for example, depleted uranium) are indicated for occupational health and radiation protection are well-defined and the assays required are well-known and tested. The same can be said for selected chemicals such as lead. Current standards of practice indicate that these biomarkers are required (sufficient justification) under the following conditions:

- The potential exists that an exposure threshold may have been exceeded. The U.S. Nuclear Regulatory Commission (for example, requires the initiation of radiological biomonitoring if radiological isotopes could be internalized in excess of 10% of the allowable limit). Similar standards exist for some chemical exposures such as lead.
- There is a requirement to check the efficacy of protection measures. In some instances, these biomarkers will be required to ensure that protective measures in place were effective. This may be particularly important when the protective measures or recommendations involve individual compliance, such as use of a respirator, avoidance, etc. It is typically important when the effectiveness cannot be verified by external monitoring, or when the exposure is multiroute and not adequately monitored in one medium such as air.

In some settings, it may be important to ascertain the level of exposure to personnel in emergent or combat situations where the presence of a toxicant is confirmed or suspected and sampling equipment is not available. Perceived risks on the ground are important to address. The ability to rapidly and effectively respond to service member concerns in a trustworthy manner is an effective countermeasure to post-deployment concerns. Biomarkers may be used selectively to document the absence of significant exposure, but the ramifications of exercising this option must be considered carefully. Biomarkers may also be employed during pre- and post-deployment to

Criteria	Sufficient, Necessary, or To Be Considered
Mission Limits Collection of Exposure Data and Intelligence, Other Confirms Credible Exposure	Sufficient
Quantifies Exposure Measured Above a Relevant Standard in One or More Media (Completed Exposure Pathway)	Sufficient
Question Regarding Effectiveness of Protective Measures	Sufficient
Validated Biomarker Exists to Characterize Risk	Necessary
Availability of Population Normal Referent Range	Necessary
High Sensitivity	Necessary
High Specificity	Necessary
Relatively Non-invasive	Necessary
Logistically Feasible	Necessary
Sufficient Medical /Risk Communication Assets Available	Necessary
Current Use as Standard of Care for Exposure/Hazard	Necessary
Result Translates Into Specific Action or Message	Necessary
Group for Which Follow-up May be Difficult (Reserve/Guard)	To Be Considered
High Predictive Value of Disease or Outcome	To Be Considered
Exposure-Disease Relationship:	
Measures Exposure	To Be Considered
Measures “Critical Effect”	To Be Considered
Measures Adverse Effect	To Be Considered
Influence of Confounding Exposures	To Be Considered
Limited Age/Sex/Race Variability	To Be Considered
Reflects Recent Exposures	To Be Considered
Reflects Integrated Exposures	To Be Considered
Question Regarding Compliance with Protective Measures	To Be Considered

*Table 1. Operationally Indicated Biomarkers: Credible Acute Health Hazard*

assess phase-related shifts for toxicants that may produce only delayed health effects in certain settings when this information is deemed critical and not available by any other methods.

The test itself must provide reliable, interpretable health data that is useful to the service member, the medical profession, and/or the commander and the operation. In situations where the use of biomonitoring is justified, test performance must be considered, and biomonitoring should not be done if the test is inadequate. Tests that are unreliable or provide results that cannot be interpreted, translated into meaningful risk statements, or used in risk assessment or verification that protective measures worked may not be of any use to the service member or the operation.

It is critical that it be feasible to properly execute the entire

test cycle to include informing the service member of the results of the tests and the meaning of the results relative to the service member’s health, with minimal operational disruption. Biomarkers intended to assess the potential for delayed health effects will not be perceived as valuable to operational unit commanders if the units are asymptomatic and unconcerned. In this instance, biomonitoring for strategic interests will not be perceived to provide the value added to justify the inconvenience and mission disruption, even if minimal. Biomonitoring with a heavy logistical burden due to sample collection and shipment requirements will be viewed as disruptive. For example, testing that depends upon specimens that must be shipped frozen to the continental U.S. requires conditions not always possible in a deployed setting. Resources needed to accomplish this must also be considered.

Criteria	Sufficient, Necessary, or to be Considered
Accurately Quantifies Credible Exposure to Toxicant of High Concern (Radiation/Carcinogen/Chemical Warfare Agent)	Sufficient
Desire to Document/Archive Credible Exposures for Potential Retrospective Use	Sufficient
Question Regarding Effectiveness of Protective Measures to Toxicant with Delayed Effects	Sufficient
High Sensitivity	Necessary
High Specificity	Necessary
Medical and Risk Communication Support Available During and Post-testing	Necessary
Relatively Noninvasive	Necessary
Logistically Feasible	Necessary
Availability of Population Normal Referent Range	Necessary
Inadequate or Incompletely Characterized External Dose	Necessary
Group for which Follow-up May Be Difficult (Reserve/Guard)	To Be Considered
Current Use as Standard of Care for Exposure/Hazard	To Be Considered
Results Translate Into a Specific Action or Message	To Be Considered
High Predictive Value for Disease or Outcome	To Be Considered
Exposure-Disease Relationship:	
Measures Exposure	To Be Considered
Measures “Critical Effect”	To Be Considered
Measures Adverse Effect	To Be Considered
Influence of Confounding Exposures	To Be Considered
Limited Age/Sex/Race Variability	To Be Considered
Reflects Recent Exposures	To Be Considered
Reflects Integrated Exposures	To Be Considered
Reflects Cumulative Exposures	To Be Considered
Samples Can Be Frozen for Future Analysis	To Be Considered
Desire to Establish Means and Norms for Hazard	To Be Considered

*Table 2. Strategically Indicated Biomarkers*

Risk communication at all levels is a vital part of the use of biomarkers and is required to counter the risks posed by the use of biomarkers. Engendering the trust of our service members, marines, sailors, airmen, commanders, their families, the media, our allies, and the U.S. Congress is a critical part of this effort. Technical accuracy, candor, and having an effective plan to communicate risks to each of these groups will be an integral part of the planning and execution of this effort. Each phase of the plan will be practiced to the greatest extent possible to ensure the accuracy and completeness of the process.

Tables 1 and 2 contain the criteria for use in determining

whether biomarkers are appropriate. These criteria will be used when biomonitoring is considered: (1) operationally relevant or (2) strategically relevant. If a “sufficient” criterion is met, the appropriate biomarker is considered against “necessary” and “to be considered” criteria. A situation may be “sufficient” to initiate consideration of biomonitoring, but the individual test must meet the “necessary” criteria. “To be considered” criteria play a lesser role in decision making. Table 3, on the following page, provides current candidates for biomarkers of exposure. For example, consider that a radiation hazard is deemed a credible health hazard in the deployed setting at a specific location. Monitoring is conducted, and the levels do not exceed

Toxicant	Media	Range of Detection	Requires Baseline or Comparison Population	Comments
Nerve Agent	Urine	Below Clinical Effects Levels	No	Specificity Critical
Nerve Agent: Cholinesterase	Blood: Finger Prick (on-site)	Detects Change from Baseline	Yes	High variability, poor correlation with clinical effects
Sulfur Mustard	Urine	Below Clinical Effects	No	Specificity Critical
Depleted Uranium	Urine	Pico Curie/L	Yes	Must speciate
“Radiation”	Lymphocyte DNA damage Urine	Sensitive	Yes	Complex interpretation; recommend archiving samples
Metals	Blood/Urine/Hair	Parts Per Trillion	Yes	Variable public health importance
Volatile Organic Compounds	Blood	Part Per Trillion	Yes	Rapidly metabolized, little clinical implications
	Urine	Occupational Range		
Polyaromatic Hydrocarbons (PAHs)	Urine	Low-Level	Yes	PAHs are heterogeneous group; exposure sources variable
	Blood: DNA adducts			
Dioxins/Polychlorinated Biphenyls	Fat	Below Clinical Effects Level	Yes	Cumulative; difficult to identify time of exposure

Table 3. Candidate Biomarkers of Exposure

any relevant standard. In this instance, using the acute hazard criteria, the “sufficient” criteria have not been met, and biomonitoring would not be warranted. If, instead, the mission limits the collection of exposure data, but intelligence preparation of the battlefield confirms a credible hazard, a “sufficient” criterion has been met. Consideration of a specific biomarker now moves to the “necessary” criteria. If the hazard is depleted uranium and the biomarker is uranium in urine, the majority of the “necessary” criteria could be met by this test since it is validated, sensitive, and relatively noninvasive, in current use and a population reference range exists. Further “necessary” criteria such as logistic feasibility and availability of medical and risk communication assets may or may not be met depending on the situation. Further refinement of the decision making is performed using the “to be considered” criteria. A decision specific to the situation and scenario can be made and documented. If the hazard was ionizing radiation and the biomarker was lymphocyte damage testing (deoxyribonucleic acid (DNA) adducts), many of the “necessary” criteria would

not be met, and the consideration might stop at that point and be documented.

### Conclusion

Biomonitoring is a powerful tool when used appropriately. The results can be used to assess the degree of exposure and may provide important information needed to assess required follow-up. In some situations of high concern, negative results may serve to demonstrate that untoward exposure was unlikely. Conventional wisdom would indicate that providing individuals with negative test results is reassuring. In reality, for some patients not particularly concerned about their health, negative results may provide reassurance.<sup>13</sup> In individuals with preexisting anxiety regarding their health, or vague symptoms, the medical consultation and negative results do little to change the patient’s health risk belief and do not reassure.<sup>14</sup> At worst, patients may become defensive and frustrated if test results are negative, and there is some indication that diagnostic testing

may cause healthy people to feel ill.<sup>15,16</sup> Use of biomonitoring will benefit from an understanding of how service members respond to results that indicate the presence of low levels of various contaminants in their blood or urine, even though considered “negative” or no different than the general population. Such a study is planned for the members of a cohort evaluated with biomonitoring on a recent deployment. The study may be important in shaping the role of biomonitoring in the future.

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## **Combat Medic Prayer**

*Oh Lord. I ask for the divine strength to meet the demands of my profession. Help me to be the finest medic, both technically and tactically. If I am called to the battlefield, give me the courage to conserve our fighting forces by providing medical care to all who are in need. If I am called to a mission of peace, give me the strength to lead by caring for those who need my assistance. Finally, Lord, help me to take care of my own spiritual, physical, and emotional needs. Teach me to trust in your presence and never-failing love.*

*Amen*

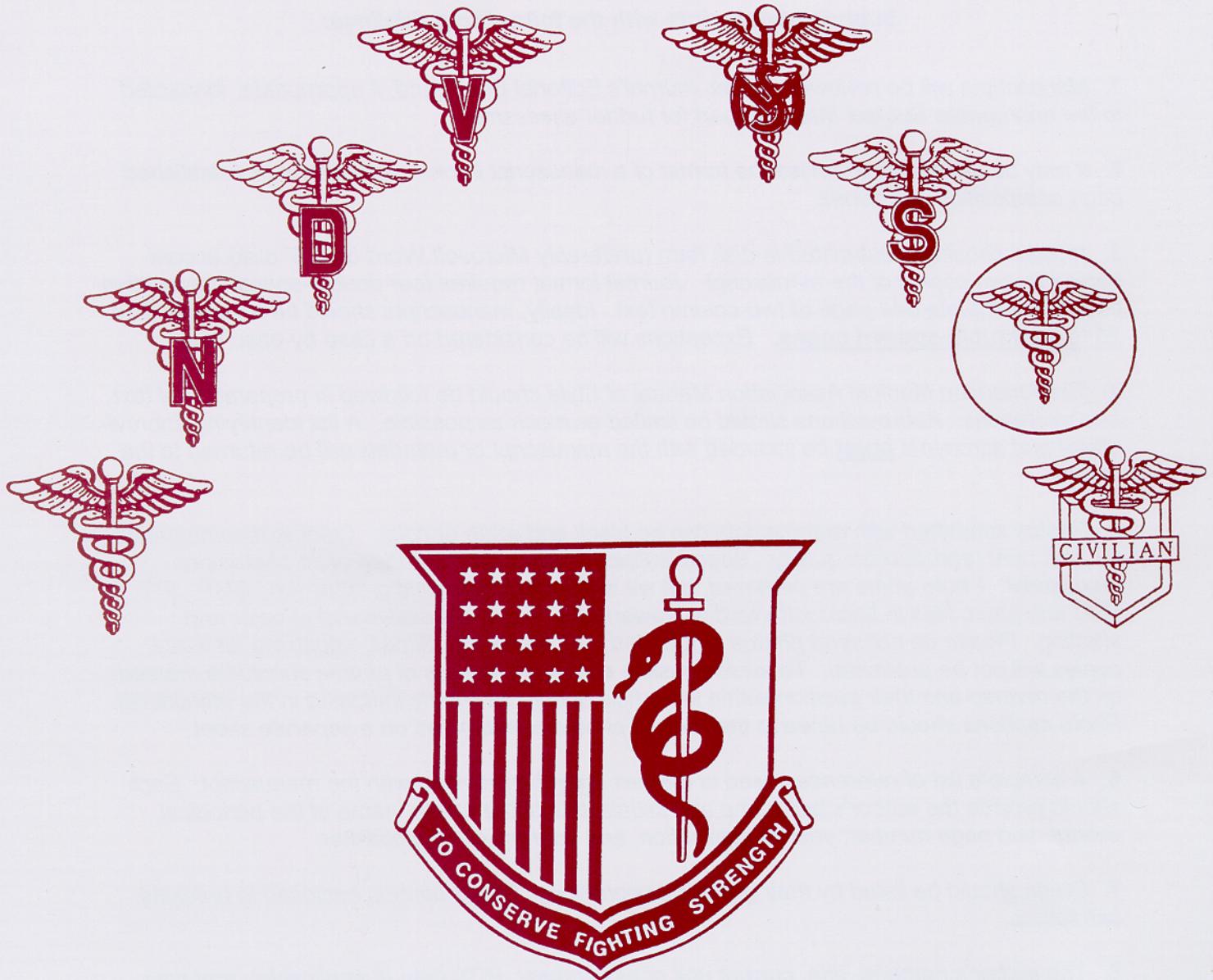


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4. *The American Medical Association Manual of Style should be followed in preparation of text and references. Abbreviations should be limited as much as possible. A list identifying abbreviations and acronyms **must** be included with the manuscript or materials will be returned to the author.*
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